Department of Energy
Carlsbad Area Office
P. O. Box 3090
Carlsbad, New Mexico 88221

November 15, 1996

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Dear Citizen:

Enclosed for your information and review is a copy of the Draft Supplemental Environmental Impact Statement for the Waste Isolation Pilot Plant Disposal Phase (DOE/EIS-0026-S-2), or the summary of that document if you requested only the summary.

The Draft Statement was prepared by the Department of Energy (DOE) to assess the potential environmental impacts of six alternatives for disposal of DOE transuranic waste. The proposed action is to dispose of transuranic waste packaged to meet planning basis Waste Isolation Pilot Plant (WIPP) Waste Acceptance Criteria (that involves minimal treatment to meet worker safety, transportation and disposal requirements) at WIPP, up to the volume limits imposed by legislation. Three other alternatives involve disposal of all DOE transuranic waste at the WIPP after varying levels of treatment (packaging to meet planning basis WIPP Waste Acceptance Criteria; shred and grout treatment; and thermal treatment to destroy hazardous constituents to meet Resource Conservation and Recovery Act land disposal requirements). Two no-action alternatives: continued storage at waste generator sites in existing facilities and continued storage at the generator sites in newly constructed monitored retrievable storage facilities are also examined.

DOE is interested in any comments you wish to provide regarding this document.

As part of the public review period, DOE will hold several public hearings for receiving oral comments. The locations of these meetings are:

Albuquerque, NM	January 6 -7, 1997	Albuquerque Convention Center
Santa Fe, NM	January 8 - 10, 1997	Sweeney Convention Center
Carlsbad, NM	January 13, 1997	Pecos River Village
Denver, CO	January 13, 1997	Arvada Center
Boise, ID	January 15, 1997	Red Lion Inn Riverside
Richland, WA	January 15, 1997	Red Lion Inn Richland
Oak Ridge, TN	January 21, 1997	American Museum of Science and Energy
North Augusta, SC	January 23, 1997	North Augusta Community Center

Additional information on these meetings will be announced in the Federal Register and in a special edition of the Carlsbad Area Office's TRU Progress newsletter on or about November 29, 1996. You are invited to participate in these meetings and/or submit written comments on the Draft Statement.

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Individuals wishing to present oral comments at the public hearings are asked to preregister to speak at least one week in advance of the meeting by calling 1-800-336-9477. Individuals that request to speak and have not preregistered will be given the opportunity to speak as time allows. Written comments should be directed to Harold Johnson, NEPA Document Manager, Attn: SEIS comments, P.O. Box 9800, Albuquerque, NM 87119. Comments may be faxed to (505) 224-8030. Comments submitted via electronic mail should be addressed to WIPPSEIS@battelle.org.

If you require further information, please contact the WIPP information line at 1-800-336-9477.

Sincerely,

George E. Dials
Manager

Enclosure:

WIPP Library

DOE/EIS-0026-S-2

Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement

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Department of Energy
Carlsbad Area Office
Carlsbad, New Mexico

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Carlsbad Area Office
Carlsbad, New Mexico

November 1996

On September 23, 1996, the President signed into law the National Defense Authorization Act for Fiscal Year 1997, Public Law 104-201, which contains amendments to the Waste Isolation Pilot Plant Land Withdrawal Act. Effort has been made to reflect these amendments in this document. The Land Withdrawal Act amendments made Resource Conservation and Recovery Act land disposal treatment standards and restrictions inapplicable to waste to be disposed of at WIPP, thus eliminating the need to obtain a No Migration variance determination from the Environmental Protection Agency prior to commencing disposal operations. Other pertinent changes include the deletion of requirements for submission of a comprehensive disposal recommendations report to Congress, the statutory requirement that waste be retrieved if WIPP is found to be in noncompliance, and modified the requirement that the Department of Energy acquire existing oil leases prior to operation.

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Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; prices available from (423) 576-1301.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

This document is subject to revision.

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COVER SHEET

Lead Agency: U.S. Department of Energy

Title:

Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement

Contact:

For further information about this Environmental Impact Statement, contact:

Harold Johnson, WIPP EIS
U.S. Department of Energy
101 W. Greene Street
Carlsbad, NM 88220
(505) 234-7349 phone (505) 887-6970 fax

For general information on the Department of Energy's process for implementing the National Environmental Policy Act, contact:

Carol Borgstrom, Director
Office of NEPA Policy and Assistance
Office of the Assistant Secretary for Environment, Safety and Health
U.S. Department of Energy (EH-42)
1000 Independence Avenue, SW
Washington, DC 20585
(202) 586-4600 or leave a message at (800) 472-2756

Abstract:

The purpose of *the Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II) is to provide information on environmental impacts regarding the Department of Energy's (DOE) proposed disposal operations at WIPP. To that end, SEIS-II has been prepared to assess the potential impacts of continuing the phased development of WIPP as a geologic repository for the safe disposal of transuranic (TRU) waste. SEIS-II evaluates a Proposed Action, three Action Alternatives based on the waste management options presented in the *Draft Waste Management Programmatic Environmental Impact Statement*, and two No Action Alternatives. The Proposed Action describes the treatment and disposal of the Basic Inventory of TRU waste over a 35-year period. The Basic Inventory is that waste currently permitted in WIPP based on current laws and agreements. The Action Alternatives propose the treatment of the Basic Inventory and an Additional Inventory as well as the transportation of the treated waste to WIPP for disposal over a 150- to 190-year period. The three Action Alternatives include the treatment of TRU waste at consolidation sites to meet WIPP Waste Acceptance Criteria, the thermal treatment of TRU waste to meet Land Disposal Restrictions, and the treatment of TRU waste by a shred and grout process. The No Action Alternatives propose the dismantling and closure of WIPP and storage of the waste. One No Action Alternative proposes treating the waste thermally before placing it in retrievable storage.

SEIS-II evaluates environmental impacts resulting from the various treatment options; the transportation of TRU waste to WIPP using truck, a combination of truck and regular rail service, and a combination of truck and dedicated rail service; and the disposal of this waste in the repository. Evaluated impacts include those to the general environment and to human health. Additional issues associated with the implementation of the alternatives are discussed to provide further understanding of the decisions to be reached and to provide the opportunity for public input on improving DOE's Environmental Management Program.

Additional Information:

Written comments on the WIPP SEIS-II should be sent to the address provided in the Notice of Availability published in the *Federal Register*. To be considered in the preparation of the Final WIPP SEIS-II, all comments should be submitted within 60 days after the Notice of Availability. Public hearings will be held at the dates and times specified in the Notice of Availability. Oral comments on SEIS-II can be made at the public hearings. Copies of the SEIS-II and its supporting documents can be found in the public Reading Rooms listed in the Notice of Availability.

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GLOSSARY

GLOSSARY

actinide	An element in the series beginning with element 89 (actinium) and continuing through element 103 (lawrencium). All the transuranic nuclides considered in this document are actinides.
activity	A measure of the rate at which a material emits nuclear radiation, usually given in terms of the number of nuclear disintegrations occurring in a given length of time. The common unit of activity is the curie, which amounts to 37 billion disintegrations per second. The International Standard unit of activity is the becquerel and is equal to one disintegration per second.
aerosolize	The process of converting a solid or a liquid into an airborne suspension of fine particles (an aerosol).
aggregate	The sum total; for purposes of SEIS-II, the accumulated effect or quantity by successive additions, often over time.
air quality	A measure of the quantity of pollutants in the air.
alluvium	Clay, silt, sand, and/or gravel deposits found in a stream channel or in low parts of a stream valley that is subject to flooding. Ancient alluvium deposits frequently occur above the elevation of present-day streams.
alpha particle	A positively charged particle emitted in the radioactive decay of certain nuclides. Made up of two protons and two neutrons bound together, it is identical to the nucleus of a helium atom.
ambient air	The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It is not the air in immediate proximity to emission sources.
anhydrite	A mineral consisting of anhydrous calcium sulfate: $CaSO_4$.
aqueous	Related to water.
aquifer	Geologic unit sufficiently permeable to conduct groundwater.
argillaceous rocks	Rocks containing appreciable amounts of clay.
atmosphere	The layer of air surrounding the earth.
atmospheric dispersion	Movement of a contaminant as a result of the cumulative effect of the random motions of the air. Equivalent to eddy diffusion.
atom	Smallest unit of an element that is capable of entering into a chemical reaction and displays the other properties of the element.

backfill	Materials placed in storage panels or drifts.
background radiation	Radiation from: (1) naturally occurring radioactive materials, as they exist in nature prior to removal, transport, or enhancement or processing by man; (2) cosmic and natural terrestrial radiation; (3) global fallout as it exists in the environment; (4) consumer products containing nominal amounts of radioactive material or emitting nominal levels of radiation; and (5) radon and its progeny in concentrations or levels existing in buildings or the environment that have not been elevated as a result of current or past human activities.
basin	A topographic or structurally low area compared to the immediately adjacent areas.
bedded	Arranged in layers or beds. Usually, but not exclusively, applied to sedimentary deposits.
Bell Canyon Formation	A sequence of rock strata that forms the topmost unit of the Delaware Mountain Group.
berm	An earthen enbankment; a long artificial mound of stone or earht similar to a dike or levee.
bounded or bounding	Producing greater consequences than other scenarios; or would "bound" the remainder of the scenarios.
°C	Degree Celsius. °C = 5/9 x (°F - 32).
caliche	Calcium carbonate $CaCO_3$, deposited in the soils of arid or semiarid regions.
cancer	Any malignant new growth of abnormal cells or tissue.
canister	In this document, a container, usually cylindrical, for remotely handled transuranic waste. The waste will remain in this canister during and after emplacement at Waste Isolation Pilot Plant. A canister affords physical containment but not shielding; shielding is provided during shipment by a cask.
carcinogen	An agent capable of producing or inducing cancer.
carcinogenic	Capable of producing or inducing cancer.
cask	A massive shipping container providing shielding for highly radioactive materials and holding one canister.

Castile Formation	A Permian age rock unit of evaporites (interbedded halite and anhydrite) that immediately underlies the Salado Formation, the rock unit in which disposal rooms are excavated.
cloudshine	The pathway of direct external dose from the passing cloud of dispersed radioactive material.
commercial waste	Nuclear waste deriving from commercial sources. These are principally power reactors, but also include research laboratories and medical facilities.
committed dose equivalent	The predicted dose equivalent to a tissue or organ over a 50-year period after an intake of a radionuclide into the body. It does not include dose contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or seivert). (1 rem = 0.01 seivert).
committed effective dose equivalent	The sum of the committed dose equivalents to various organs or tissues in the body from radioactive material taken into the body, each multiplied by the tissue-specific weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).
community	A group of people or a site within a spatial scope exposed to risks that potentially threaten health, ecology, or land values, or exposed to industry that stimulates unwanted noise, odors, industrial traffic, particulate matter, or other nonaesthetic impacts.
concentration	The amount of a substance contained in a unit quantity (mass or volume) of a sample.
conservative	When used with predictions or estimates, leaning on the side of pessimism. A conservative estimate is one in which the uncertain inputs are used in the way that provides a reasonable upper limit of the estimate of an impact.
contact-handled transuranic waste	Waste that does not require shielding other than that provided by its container to protect those handling it from radiation exposure. The radiation level at the outer surface of the container is specified as no more than 200 millirem per hour.
containment	Retention of a material or substance within prescribed boundaries.
contamination	The presence of excess radioactive material from a U.S. Department of Energy activity in or on a material or property.
creep	The continuous, usually slow deformation of solid rock resulting from constant strain acting over a long period of time. Salt will creep much faster than limestone, in a manner similar to ice in a glacier.

creep closure	Closure of underground openings, especially openings in salt, by creep flow of the surrounding rock under lithostatic pressure.
criteria pollutants	Six pollutants (ozone, carbon monoxide, total suspended particulates, sulfur dioxide, lead, and nitrogen oxide) known to be hazardous to human health and for which the U.S. Environmental Protection Agency sets National Ambient Air Quality Standards under the Clean Air Act.
critical habitat	The specific areas within the geographical area occupied by a species at the time it is listed as threatened or endangered on which are found those physical on biological features that are essential to the conservation of the species and that may require special management considerations or protection. It also includes specific areas outside the geographical area occupied by the species at the time it is listed if these areas are determined to be essential for the conservation of the species.
criticality	A state in which a self-sustaining nuclear chain reaction is achieved.
Culebra Dolomite	The lower of two geologic units of water-bearing dolomite within the Rustler Formation.
cumulative impacts	Cumulative impacts are those impacts on the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.
curie	A unit of radioactivity equal to 37 billion (3.7×10^{10}) disintegrations per second.
Darcy's law	A mathematical relationship that describes the flow through porous media.
daughter	Synonym for decay product.
decommissioning	The removal from active service of a facility.
decontamination	The removal of unwanted material (especially radioactive material) from the surface or from within another material.
defense waste	Nuclear waste deriving from the manufacture of nuclear weapons and the operation of naval reactors. Associated activities, such as the research carried on in the weapons laboratories, also produce defense waste.
degradation	A process of transition. To decompose (a compound) by stages.
Delaware Basin	An area in southeastern New Mexico and the adjacent parts of Texas where the Permian sea deposited a large thickness of evaporites some 220 to 280 million years ago. It is partially surrounded by the Capitan Reef.

design life	The design life of components or systems generally refers to the estimated minimum period of time that the component or system is expected to perform within specifications before the effects of aging result in performance deterioration or a requirement to replace the component or system.
diffusion	Movement of atoms, ions, or molecules of one substance into or through another as a result of thermal or concentration gradients.
diffusion, molecular	Movement of a contaminant as the result of the cumulative effect of the random motions of molecules along a concentration or thermal gradient.
disposal	In this document, permanent disposition of waste in a repository. Use of the word "disposal" implies that no need for later retrieval is expected. It also implies a minimal need for surveillance.
Disposal Phase	The period in which the U.S. Department of Energy proposes to permanently emplace transuranic wastes in the Waste Isolation Pilot Plant.
dissolution	The process whereby a material is taken into solution. Selective dissolution of minerals may produce cavities and caves, or enlarged fractures in a rock formation.
dissolution front	The boundary of a geologic region within which rock is dissolving. In this document, the term particularly refers to the wedge-like leading edge of salt dissolution at the interface between the Rustler and Salado Formation.
distribution coefficient	In an aquifer, the ratio of the concentration of a substance absorbed by the rock to the concentration of the substance remaining in solution. A large distribution coefficient implies that the substance moves much more slowly than the groundwater. It is measured in units of cubic centimeters per gram or equivalent.
disturbed rock zone	The disturbed rock zone is a volume of rock adjacent to an underground excavation in which mechanical properties (e.g., elastic modulus) and hydraulic properties (e.g., permeability and degree of saturation) have been changed because of the excavation.
dolomite	A sedimentary rock consisting primarily of the mineral dolomite: $CaMg\ (CO_3)_2$.
dose (absorbed dose)	The energy imparted to matter per unit mass by ionizing radiation. The unit of absorbed dose is the rad. In SEIS-II, it is used as a general term for dose equivalent, total effective dose equivalent, and committed dose equivalent.
dose conversion factor	A numerical factor used in converting radionuclide intake (curies) in the body to the resultant radiation dose (rem or person-rem).

dose equivalent	The product of absorbed dose in rad (or gray) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert).
dose rate	The radiation dose delivered per unit time (e.g., rem per hour).
dual porosity	Having fracture porosity as well as interconnected pores (matrix porosity).
ecology	The science dealing with the relationship of all living things with each other and with the environment.
economic sector	A distinctive part of the economy of a geographic region defined by a standard industrial classification scheme. One such scheme defines "major" sectors and divides them into subsectors; for example, the major sector trade" contains the subsectors "wholesale trade" and "retail trade." Another classification scheme specifies "primary" and "secondary" sectors; the criterion for including a sector in the primary classification is that its level of activity is generally not controlled by the level of economic activity in the region; a primary industry, in other words, produces goods and services for export from the region.
effective dose equivalent	The sum of the products of the dose equivalent received by specified organs or tissues of the body and a tissue-specific weighting factor. The effective dose equivalent is expressed in units of rem (or sievert).
effluent	Liquid or airborne material released to the environment. In common usage, however, the term "effluent" implies liquid release.
EIS	Environmental impact statement; a document required by the National Environmental Policy Act for proposed major Federal actions involving potentially significant environmental impacts.
element	One of the known chemical substances that cannot be divided into simpler substances by chemical means.
endangered species	Plants and animals that are threatened with extinction, serious depletion, or destruction of critical habitat. Requirements for declaring a species endangered are contained in the Endangered Species Act.
energy	The capacity for doing work.
environment	The sum of all external conditions and influences affecting the life development and, ultimately, the survival of an organism.
environmental monitoring	The act of measuring, either continuously or periodically, some quantity of interest, such as radioactive material in the air.
ephemeral stream	A stream channel that carries water only during part of the year, immediately after periods of rainfall or snowmelt.

equilibrium	A state of rest in a chemical or mechanical system. Chemical: The state of a reaction in which its forward and reverse reactions occur at equal rates so that the concentrations of the reactants do not change with time. Mechanical: Forces in one direction are equal and opposite to those in the opposing direction. Flow of salt to fill the excavated cavity is an attempt by the salt to reattain a state of mechanical equilibrium.
erosion	Removal and transport of materials by wind, ice, or water on the earth's surface.
evaporite	A sedimentary rock composed primarily of minerals produced by partial or total evaporation of sea water.
evapotranspiration	Loss of water from the earth's surface to the atmosphere by a combination of evaporation from the soil, lakes, streams, and transpiration from plants.
exposure	A measure of the ionization produced in air by X or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element.
°F	Degree Fahrenheit. °F = (°C x 9)/5 +32.
fault	A fracture or a zone of fractures along which there has been displacement parallel to the fracture.
fissile	Describes a nuclide that undergoes fission on absorption of neutrons of any energy.
fission (nuclear)	The splitting of a heavy nucleus typically into two approximately equal parts (infrequently three parts), which are nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or can be induced by nuclear bombardment.
fission product	An element or compound resulting from fission.
formation	A mappable geologic body of rock identified by lithic characteristics and stratigraphic position. Formations may be combined into groups or subdivided into members.
40 CFR Part 191	The U.S. Environmental Protection Agency standard for managing and disposing of spent nuclear fuel and high-level and transuranic wastes. Subpart A deals with managing and storage of wastes, while Subpart B covers long-term isolation and disposal.
fraction	A small part of the total. The particulate fraction is that part of the waste in a particulate form.

gamma	Short-wavelength electromagnetic radiation (high-energy photons) emitted in the radioactive decay of certain nuclides. Gammas are the same as gamma rays or gamma waves.
geology	The science that deals with the earth; the materials, processes, environments, and history of the planet, especially the lithosphere, including the rocks, their formation, and structure.
gross alpha	The total rate of alpha particle emission from a sample, without regard to energy distribution or source nuclides.
gross beta	The total rate of emission of beta particles from a sample, without regard to energy distributions or source nuclides.
groundshine	The pathway of direct external dose from radioactive material that has deposited on the ground after being dispersed from the accident site.
groundwater	All subsurface water, especially that contained in the saturated zone below the water table.
gypsum	A soft mineral consisting of hydrous calcium sulfate: $CaSO_4 \cdot 2H_20$.
habitat	The part of the physical environment in which a plant or animal lives.
half-life	Time required for a radionuclide to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life; that is, half of a particular radionuclide will decay in a specified amount of time; then half of the remaining portion will decay in the same amount of time, and so on. Half-life can also refer to the length of time that a chemical/radionuclide/ biological agent remains in the body. Each material has biologically unique half-lives, depending on the substance, the organ of concern, and its route of elimination.
halite	A mineral composed of sodium chloride, NaCl.
hazard index	An indicator of the potential toxicological hazard from exposure to a particular substance. The hazard index is equal to an individual's estimated exposure divided by the U.S. Environmental Protection Agency's substance-specific reference dose.
hazardous waste	Hazardous constituents regulated by the Resource Conservation and Recovery Act and defined in 40 CFR 261 Subparts C and D.
head	When used in a hydraulic sense, it is understood to mean static head. The static head is the height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point.
headspace	The space between the container lid and the waste inside the container.

high efficiency particulate air filter	This filter is designed to remove 99.9 percent of particles as small as 0.3 micrometer in diameter from a flowing air stream.
high-level waste	The highly radioactive waste material that results from the reprocessing of spent nuclear fuel. High-level waste may include other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.
historic resources	The sites, districts, structures, and objects associated with historic events, persons, or social or historic movements.
horizon	A particular layer in a sequence of rock units. The waste-emplacement horizon in the Waste Isolation Pilot Plant is a specific level about 655 meters (2,150 feet) below the surface in the Salado Formation at which openings are being excavated for waste disposal.
hot cell	A heavily shielded enclosure for handling and processing (by remote means or automatically) or storing highly radioactive materials.
hydraulic conductivity	A quantity that describes the rate at which water flows through an aquifer. It has units of length/time and is equal to the hydraulic transmissivity divided by the thickness of the aquifer.
hydraulic gradient	A quantity that describes the rate of change of pressure head per unit of distance of flow at a given point and in a given direction.
igneous	A rock or mineral that crystallizes from magma, molten rock.
immediately dangerous to life and health	A term that represents a maximum airborne concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.
in situ	In the natural or original position; i.e., in place.
intensity (earthquake)	A measure of the effects of an earthquake on humans and structures at a particular place. It is measured in numerical units on the modified Mercalli scale.
interbed	A bed of one kind of rock occurring between or alternating with beds of another rock type.
ionization	The process that creates ions. Nuclear radiation, X-rays, high temperatures, and electric discharges can cause ionization.
ionizing radiation	Radiation capable of displacing electrons from atoms or molecules to produce ions.

isotope	An atom of a chemical element with a specific atomic number and atomic weight. Isotopes of the same element have the same number of protons but different numbers of neutrons. Isotopes are identified by the name of the element and the total number of protons and neutrons in the nucleus. For example, uranium-235 is an isotope of uranium with 92 protons and 143 neutrons and uranium-238 is an isotope of uranium with 92 protons and 146 neutrons.
karst	A topography characterized by sinkholes, caves, and disappearing streams formed by dissolution in limestone, dolomite, and evaporite bedrock.
kelvin	A unit of temperature, abbreviated K, equal to the degree Celsius expressed as: °K = °C+273.
latent cancer fatalities	Deaths resulting from cancer that has become active after a latent period following radiation exposure. Latent cancer fatalities can be calculated for the public by using the risk conversion factor of $5x10^{-4}$ deaths per person-rem and for the worker by using the risk conversion factor of $4x10^{-4}$ deaths per person-rem.
leaching	The process of extracting a soluble component from a solid by the percolation of a solvent, such as water, through the solid.
lineament	A geologic term for straight or gently curved, linear topographic features.
lithostatic pressure	The vertical pressure at a point in the earth's crust equal to the weight of the overlying column of rock.
Los Medaños	The area in southeastern New Mexico surrounding the Waste Isolation Pilot Plant site. In English, it means "dune country."
low-income population	A population where 25 percent or more of the population is identified as living in poverty.
low-level waste	Radioactive waste not classified as high-level waste, transuranic waste, or uranium or thorium mill tailings.
Magenta Dolomite	The upper of the two dolomite layers within the Rustler Formation that are locally water-bearing.
magnitude (earthquake)	A measure of the total energy released by an earthquake. It is commonly measured in numerical units on the Richter scale. Each unit, e.g. 7, is different from an adjacent unit by a factor of 30.

maximally exposed individual (MEI)	A hypothetical member of the public who is exposed to a release of radioactive or chemically hazardous material in such a way (by combination of location, dietary habits, etc.) that the individual will likely receive the maximum dose from such release.
member	A division of a formation differentiated by separate or distinct lithology or complex of lithologies.
migration	The natural travel of a material through the air, soil, or groundwater.
mitigate	To take practicable means to avoid or minimize environmental harm from a selected alternative.
molecular weight	The weight of a molecule of a chemical expressed in atomic mass units.
Nash Draw	A shallow 8-kilometer- (5-mile-) wide valley open to the southwest located to the west of the Waste Isolation Pilot Plant site.
National Environmental Policy Act	This Act was designed to promote inclusion of environmental concerns in Federal decision-making.
National Register of Historic Places	A list maintained by the National Park Service of architectural, historic, archaeological, and cultural sites of local, state, or national importance.
noninvolved worker	For this document, a worker who is not involved in the operation of a facility when a radioactive release occurs.
NO_x	Oxides of nitrogen, primarily nitrogen oxide and nitrogen dioxide. These are produced primarily by combustion of fossil fuels, and can constitute an air pollution problem.
nuclide	A species of atom, characterized by its number of protons, number of neutrons, and energy state.
order of magnitude	A multiple of ten. When a measurement is made with a result such as 3×10^7, the exponent of 10 (here 7) is the order of magnitude of that measurement. To say that this result is known to within an order of magnitude is to say that the true value lies between (in this example) 3×10^6 and 3×10^8.
organic compounds	Of or designating carbon compounds. (Some simple compounds of carbon, such as carbon dioxide, are frequently classified as inorganic compounds.)
overpack	A container put around another container. In the Waste Isolation Pilot Plant, overpacks would be used on damaged or otherwise contaminated drums, boxes, and canisters that it would not be practical to decontaminate.

oxide	A compound consisting of an element combined with oxygen.
ozone	A molecule of oxygen in which three oxygen atoms are chemically attached to each other.
package	In the regulations governing the transportation of radioactive materials, the packaging together with its radioactive contents as presented for transport.
packaging	A shipping container without its contents.
particulates	Solid particles and liquid droplets small enough to become airborne.
PE-Ci	Plutonium-239 equivalent curies are used as a radioactive hazard index factor that relates the radiotoxicity of transuranic radionuclides to that of plutonium-239.
permeability	The capability of a soil or rock to transmit a fluid.
person-rem	A measure of the radiation dose to a given population; the sum of the individual radiation doses received by that population.
pH	A measure of the hydrogen ion concentration in aqueous solution. Pure water has a pH of 7, acidic solutions have a pH less than 7, and alkaline solutions have a pH greater than 7.
physiographic	Geographic regions based on geologic setting.
planning-basis Waste Acceptance Criteria	The U.S. Department of Energy document, currently in revision number 5, that describes the criteria by which unclassified transuranic waste will be accepted for emplacement at the Waste Isolation Pilot Plant and the basis on which these criteria were established. The current planning basis for waste acceptance criteria is a compendium of the minimal requirements established by law, regulation, and U.S. Department of Energy orders that transuranic waste must meet to be transported to and disposed of at the Waste Isolation Pilot Plant (assuming the U.S. Department of Energy's planned no-migration petition is granted). The Supplemental Environmental Impact Statement-II analyses (or denial of the no-migration petition) could result in modifications to the planning-basis waste acceptance criteria.
PM_{10}	Particulate matter with a 10-micron or less aerodynamic diameter.
point source	A source of effluents that is small enough in dimensions that it can be treated as if it were a point. The converse is a diffuse source. A point source can be either a continuous source or a source that emits effluents only in puffs or for a short time.

pollution	The addition of an undesirable agent to the environment in excess of the rate at which natural processes can degrade, assimilate, or disperse it.
polyhalite	A relatively hard and brittle evaporite mineral: $K_2MgCa_2(SO_4)_4 \cdot 2H_2O$. In the Delaware Basin, it is often associated with anhydride.
population dose	The sum of the radiation doses received by the individual members of a population.
porosity	Percentage of void space in a material.
potash	Potash is the common industrial term for potassium in various chemical combinations with sodium, magnesium, chlorine, and sulfate.
potentiometric surface	Surface to which water in an aquifer would rise by hydrostatic pressure. It is usually represented in figures as a contour map, in which each point indicates how high the water would rise in a well tapping that aquifer at that point.
progeny	Stable or radioactive elements formed by the radioactive decay of another nuclide, which is the "parent."
pyrophoric	Spontaneously igniting in air; producing sparks by friction.
Quality Factor	A modifying factor used to calculate the dose equivalent from absorbed dose. The quality factor can vary by type and energy of the ionizing radiation.
radiation	Ionizing radiation; e.g., alpha particles, beta particles, gamma rays, X-rays, neutrons, protons, and other particles capable of producing ion pairs in matter. As used in this document, radiation does not include nonionizing radiation.
radioactive decay	The spontaneous transformation of one nuclide into a different nuclide or into a different state of the same nuclide. The process results in the emission of nuclear radiation (alpha, beta, or gamma radiation).
radioactive waste	Materials from nuclear operations that are radioactive or are contaminated with radioactive materials and for which there is no practical use or for which recovery is impractical.
radioactivity	The property or characteristic of radioactive material to undergo spontaneous transformations ("disintegrations" or "decay") with the emission of energy in the form of radiation. It means the rate of spontaneous transformations of a radionuclide. The unit of radioactivity is the curie (or becquerel). (1 curie = 3.7×10^{10} becquerel).
radionuclide	A nuclide that emits radiation by spontaneous transformation.

radionuclide inventory	A list of the kinds and amounts of radionuclides in a container or a source. Amounts are usually expressed in activity units: curies or curies per unit volume.
recharge	In groundwater hydraulics, the addition of water to the zone of saturation; also, the amount of water added.
Record of Decision	The document, publicly available, by which a Federal department or agency decides on an alternative presented and evaluated through the environmental impact statement process.
reference dose	The reference dose is an estimate of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a portion of the lifetime (subchronic reference dose), or during a lifetime (chronic reference dose).
rem	A common (or special) unit of dose equivalent, effective dose equivalent, or committed dose equivalent.
remote-handled transuranic waste	Waste that requires shielding in addition to that provided by the container to protect people nearby from radiation exposure. By definition, the radiation level at the outer surface of the container is greater than 200 millirem per hour and less than 1,000 rem per hour.
repository	A facility for disposal of radioactive waste.
reserves	Mineral resources that can be extracted profitably by existing techniques and under present economic conditions.
Resource Conservation and Recovery Act	This Act was designed to provide "cradle to grave" control of hazardous chemical wastes.
resources	Mineralization that is concentrated enough, in large enough quantity, and in a physical and chemical form such that its extraction may be possible in the future.
retrievable storage	Storage of radioactive waste in a manner designed for recovery without loss of control or release of radioactivity.
RH-72B	A packaging designed to transport remote-handled transuranic waste. The cask is a right, circular cylinder providing shielding from the radioactive contents. The cask is designed to provide double containment of a vented canister that is 3 meters (10 feet) long by 0.67 meter (2.2 feet) in diameter. The vented canister weighs 1,000 kilograms (2,200 pounds) and has a payload of approximately 2,631 kilograms (5,800 pounds), which is approximately 0.89 cubic meters (31 cubic feet) of waste.

risk	The likelihood of suffering a detrimental effect as a result of exposure to a hazard. In accident analysis, the probability weighted consequence of an accident, defined as the accident frequency per year multiplied by the consequence.
runoff	The portion of rainfall, melted snow, or irrigation water that flows across the ground surface and either infiltrates or eventually returns to streams.
Rustler Formation	The evaporite beds, including mudstones, of Permian age that immediately overlie the Salado Formation in which the Waste Isolation Pilot Plant disposal levels are built.
Salado Formation	The Permian Age evaporite unit within which wastes would be disposed of in the Waste Isolation Pilot Plant repository.
San Simon Swale	A broad depression about 24 kilometers (15 miles) east of the Los Medaños site, open to the southeast.
scenario	A set of conditions presumed for the purpose of estimating doses by analysis.
seismicity	All of the earthquakes that may occur in a region , regardless of magnitude.
shaft	A man-made hole, either vertical or steeply inclined, that connects the surface with an underground excavation.
shield	Material used to reduce the intensity of radiation that would irradiate personnel or equipment.
slurry	A suspension of fine particles in a liquid, in which the solid constituents are easily carried along by the liquid.
solubility	The degree to which a compound in its pure state will dissolve; water is the solvent used for determining aqueous solubility of a compound.
sorption	The binding on a microscopic scale of one substance to another, such as by adsorption or ion exchange.
source term	The kinds and amounts of radionuclides that may lead to an assumed release of radioactive material.
spent fuel or spent nuclear fuel	Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated.
storage	Temporary placement of waste in a facility. Storage usually implies the need for continued surveillance.
strata	Layers of rock.

stratigraphy	The study of layered sequences of rocks.
surface water	A creek, stream, river, pond, lake, bay, sea, or other waterway that is directly exposed to the atmosphere.
tectonic activity	Movement of the earth's crust, produced by internal forces, such as uplift, subsidence, folding, faulting, and seismic activity.
Ten Drum Overpacks	A metal container (73 inches high and 72 inches in outside diameter) similar to the standard waste box, designed to efficiently use the inner containment vessel of the TRUPACT-II. Authorized packaging configurations are as follows: ten 55-gallon drums, one standard waste box, or four 55-gallon drums within a standard waste box.
threatened species	Any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Requirements for declaring a species endangered are contained in the Endangered Species Act.
throughput	The number of TRUPACT-IIs and RH-72Bs capable of being processed at the WIPP Waste Handling Building in a given time period (i.e., 50 TRUPACT-IIs and 8 RH-72Bs per week).
total effective dose equivalent	The sum of the effective dose equivalent from radiation sources external to the body during the year plus the committed effective dose equivalent from radionuclides taken into the body. A 50-year time interval is assumed for determining committed dose.
TRANSCOM	A satellite-based tracking and communication system established by the U.S. Department of Energy.
transmissivity	A quantity defined in the study of groundwater hydraulics that describes the rate at which water may be transmitted through an aquifer. It has units of length^2/time.
transmutation	Any process in which a nuclide is transformed into a different nuclide, or more specifically, when transformed into a different element by a nuclear reaction.
transuranic mixed waste	Transuranic waste that is commingled with Resource Conservation Recovery Act-regulated hazardous wastes as defined in 40 CFR Part 261, Subparts C and D.
transuranic radionuclide	A nuclide with an atomic number (number of protons) greater than that of uranium (92). All transuranic radionuclides are radioactive.

transuranic waste	Waste materials (excluding high-level waste and certain other waste types) contaminated with alpha-emitting radionuclides that are heavier than uranium with half-lives greater than 20 years and occur in concentrations greater than 100 nanocuries per gram. Transuranic waste results primarily from plutonium reprocessing and fabrication as well as research activities at U.S. Department of Energy defense installations.
TRUPACT	Transuranic Package Transporter.
TRUPACT-II	TRUPACT-II is the package designed to transport contact-handled transuranic waste to the Waste Isolation Pilot Plant site. It is a cylinder with a flat bottom and a domed top that is transported in the upright position. The major components of the TRUPACT-II are an inner, sealed, stainless steel containment vessel within an outer, sealed, stainless steel containment vessel. Each containment vessel is nonvented and capable of withstanding 345 kilopascals (50 pounds per square inch) of pressure. The inner containment vessel cavity is 1.8 meters (6 feet) in diameter and 2 meters (6.75 feet) tall, with a capability of transporting fourteen 0.21-cubic-meter (55-gallon) drums, two standard waste boxes, or one 10-drum overpack.
tuff	Volcanic rock formed of welded or compacted volcanic ash.
void volume	That part of the total volume not occupied by the solid volume. The void volume may contain either liquid or gas.
volatile organic compound	Any compound containing carbon and hydrogen in combination with any other element that has a vapor pressure of 77.6 millimeters of mercury (1.5 pounds per square inch) absolute or greater under actual storage conditions.
volatilization	To evaporate at normal temperatures and pressures.
Waste Acceptance Criteria (WAC)	A set of minimum waste characteristics criteria that the U.S. Department of Energy has established as a planning basis for waste that would be emplaced at the Waste Isolation Pilot Plant. Should disposal operations at the Waste Isolation Pilot Plant be approved, TRU waste must be characterized and certified to meet these criteria before it can be accepted and emplaced at the Waste Isolation Pilot Plant. The WAC may change based on decisions in SEIS-II that change these minimum requirements.
waste form	The condition of the waste. This phrase is used to emphasize the physical and chemical properties of the waste.

Waste Isolation Pilot Plant	The facility near Carlsbad, New Mexico, that has been designated to be an experimental and operational site for evaluating disposal capabilities of bedded salt for U.S. Department of Energy-generated transuranic waste.
waste matrix	The material that surrounds and contains the waste and, to some extent, protects it from being released into the surrounding rock and groundwater. Only material within the canister (or drum or box) that contains the waste is considered part of the waste matrix.

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

3D	three dimensional
μR/hr	microroentgen per hour
AEC	U.S. Atomic Energy Commission
AIS	Air Intake Shaft
ALARA	as low as reasonably achievable
Ames	Ames Laboratory-Iowa State University
ANL-E	Argonne National Laboratory-East
ANL-W	Argonne National Laboratory-West
AQCR	Air Quality Control Regulations
ARCO	ARCO Medical Products Company
ATSF	Atchison, Topeka, and Santa Fe Railroad
BBER	Bureau of Business and Economic Research of the University of New Mexico
BCL	Battelle Columbus Laboratories
BEIR-III	1980 report of the Committee on Biological Effects of Ionizing Radiation of the National Academy of Sciences/National Research Council.
Bettis	Bettis Atomic Power Laboratory
BIR-2	Baseline Inventory Report, Revision 2
BLM	U.S. Bureau of Land Management
BNL	Brookhaven National Laboratory
Bq	becquerel
°C	degree Celsius
C&C	Agreement for Consultation and Cooperation
CAO	Carlsbad Area Office
CAST	Colorado Allstate Trucking
CCDF	Complementary Cumulative Distribution Function
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CH_4	methane
CH-TRU	contact-handled transuranic
Ci	curie
cm^2	square centimeters
CMR	Central Monitoring Room
CO	carbon monoxide
CO_2	carbon dioxide
CoC	contaminant of concern
CSR	Compliance Status Report
D&D	decontamination and decommissioning
DBE	design-basis earthquake
DCCA	Draft Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant
DCF	dose conversion factor
Department	U.S. Department of Energy
DF	dose factor

DLR	Dewey Lake Redbeds
DOE	U. S. Department of Energy
DOT	U.S. Department of Transportation
Draft WM PEIS	Draft Waste Management Programmatic Environmental Impact Statement
DRZ	disturbed rock zone
EA	Environmental Assessment
EEG	Environmental Evaluation Group
EIS	Environmental Impact Statement
EOC	Emergency Operations Center
EPA	U.S. Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
ETEC	Energy Technology Engineering Center
°F	degree Fahrenheit
FEIS	Final Environmental Impact Statement for the Waste Isolation Pilot Plant
FEPs	features, events, and processes
FFCAct	Federal Facility Compliance Act
FGE	fissile-gram-equivalent
F.I.R.E.	Fire, Insurance and Real Estate
FONSI	finding of no significant impact
FR	Federal Register
FRA	Federal Railroad Administration
ft^3	cubic feet
FY	fiscal year
GENII	Generation II Code Package
H_2S	hydrogen sulfide
Hanford	Hanford Site
HEPA	high-efficiency particulate air
HI	hazard index
hour/km	hours per kilometer
HQ	DOE Headquarters
HRCQ	highway route-controlled quantities
ICC	Interstate Commerce Commission
ICRP	International Commission on Radiological Protection
IDB	integrated data base
IDLH	immediately dangerous to life or health
IMPLAN	IMpact analysis for PLANing
INEL	Idaho National Engineering Laboratory
IRIS	Integrated Risk Information System
ISC3	Industrial Source Complex computer code
ISCLT3	Industrial Source Complex long-term model
ISCST3	Industrial Source Complex short-term model
kg	kilogram
kg/m^3	kilograms per cubic meter
Knolls	Knolls Atomic Power Laboratory
LANL	Los Alamos National Laboratory
LBL	Lawrence Berkeley Laboratory
LCF	latent cancer fatality
LDR	land disposal restrictions
LLNL	Lawrence Livermore National Laboratory

LWA	Waste Isolation Pilot Plant Land Withdrawal Act
m^3	cubic meters
MAP	Mitigation Action Plan
MB	marker bed
MEI	maximally exposed individual
mg	milligram
mg/m^3	milligrams per cubic meter
MgO	magnesium oxide
mg/s	milligrams per second
mi	mile
ml	milliliter
Mound	Mound Plant
mph	miles per hour
MRA	modular risk analysis
mrem	millirem
mrem/hr	millirem per hour
MSHA	Mining Safety and Health Administration
m/s	meters per second
NAAQS	National Ambient Air Quality Standards
NCRP	National Council on Radiation Protection and Measurements
NEFTRAN	Network Flow and Transport
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NIOSH	National Institute of Occupational Safety and Health
NM	New Mexico
NMDG&F	New Mexico Department of Game and Fish
NMDOL	New Mexico Department of Labor
NMED	New Mexico Environment Department
NMEMNR	New Mexico Energy, Minerals, and Natural Resources Department
NO_2	nitrogen dioxide
NOI	Notice of Intent
NO_x	Oxides of nitrogen
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NSC	National Safety Council
NTS	Nevada Test Site
NUTS	Nuclide Transport System
O_3	ozone
O&M	operations and maintenance
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OSHA	Occupational Safety and Health Act
Pa	Pascal
PA	Preliminary Performance Assessment for the Waste Isolation Pilot Plant
Pantex	Pantex Plant
PCB	polychlorinated biphenyl
pCi	picocurie
PE-Ci	plutonium-239 equivalent curies

PEIS	Programmatic Environmental Impact Statement
PEL	permissible exposure limit
PGDP	Paducah Gaseous Diffusion Plant
PM_{10}	particulate matter less than or equal to 10 micrometers in diameter
PNNL	Pacific Northwest National Laboratory
PPE	personal protective equipment
ppm	parts per million
ppmv	parts per million volume
PSD	prevention of significant deterioration
RBP	Radiological Baseline Program
RC	retrieval and characterization
RCRA	Resource Conservation and Recovery Act
RfD	reference dose levels
RFETS	Rocky Flats Environmental Technology Site
RH-72B	remote-handled transuranic waste shipping container
RH-TRU	remote-handled transuranic
ROD	Record of Decision
ROI	region of influence
RSPA	Research and Special Programs Administration
SAR	Safety Analysis Report
SEIS-I	Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant
SEIS-II	Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement
s/m^3	seconds per cubic meter
s/mg	seconds per milligram
SNL	Sandia National Laboratories
SNL-CA	Sandia National Laboratories, California
SO_2	sulfur dioxide
SPM	systems prioritization methodology
SRS	Savannah River Site
SVOC	semivolatile organic compound
SWIFT II	Sandia Waste Isolation Flow and Transport
TBE	Teledyne Brown Engineering
TCC	TRANSCOM Control Center
TCLP	Toxicity Characteristic Leaching Procedure
TDOP	Ten Drum Overpack
TDS	total dissolved solids
TEDE	total effective dose equivalent
TI	transportation index
TRANSCOM	Transportation Tracking and Communications System
TRC	total recordable case
TRU	transuranic
TRUCON	TRUPACT Content Codes
TRUPACT-II	Transuranic package transporter - II
TSCA	Toxic Substance Control Act
TSP	total suspended particulates
UDF	unit dose factor
UEF	unit exposure factor
UIF	unit impact factor

U of Mo	University of Missouri
USAMC	U.S. Army Materiel Command
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAC	planning-basis waste acceptance criteria
WAC-4	waste acceptance criteria, revision 4
WAC-5	waste acceptance criteria, revision 5
WHB	Waste Handling Building
WIPP	Waste Isolation Pilot Plant
WVDP	West Valley Demonstration Project

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MEASUREMENTS AND CONVERSIONS

MEASUREMENTS AND CONVERSIONS

The following information is provided to assist the reader in understanding certain concepts in this supplemental environmental impact statement (SEIS-II). Definitions of technical terms can be found in the Glossary.

EXPONENTIAL NOTATION

Exponential notation is used in SEIS-II to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, using exponential notation, as 1E+9. Translating from exponential notation to a more traditional number requires moving the decimal point either right (for a positive number after the E) or left (for a negative number after the E). If the value given is 5.0E+2, move the decimal point two places (insert zeros if no numbers are given) to the right of its present location. The result would be 500. If the value given is 5.0E-4, move the decimal point four places to the left of its present location. The result would be .0005.

ROUNDING

Some numbers in SEIS-II have been rounded, therefore sums and products throughout the document may not be consistent. A number was rounded only after all calculations using that number had been made. Numbers that are actual measurements were not rounded.

The waste volumes were rounded in the following manner:

124,756.2	rounded to	125,000
61,423.7	rounded to	61,000
1,476.4	rounded to	1,500
242.4	rounded to	240
16.7	rounded to	17
8.5	rounded to	9
0.3	rounded to	1

The total waste volumes for the proposed action were not rounded because these volumes were established by the Waste Isolation Pilot Plant Land Withdrawal Act.

UNITS OF MEASURMENT

The primary units of measurement used in this report are metric units with English equivalents enclosed in parentheses. DOE Order 5900.2A, " Use of the Metric System of Measurement," prescribes the use of this system in DOE Documents. Table MC-1 lists the mathematical values or formulas needed for conversion between metric and English units. Table MC-2 summarizes and defines the terms for units of measure and corresponding symbols found throughout this report.

Table MC-1
Metric Conversion Chart

To Convert to Metric			To Convert out of Metric		
If You Know	**Multiply By**	**To Get**	**If You Know**	**Multiply By**	**To Get**
Length					
inches	2.54	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.0328	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.60934	kilometers	kilometers	0.6214	miles
Area					
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092903	square meters	square meters	10.7639	square feet
square yards	0.8361	square meters	square meters	1.196	square yards
acres	0.40469	hectares	hectares	2.471	acres
square miles	2.58999	square kilometers	square kilometers	0.3861	square miles
Volume					
fluid ounces	29.574	milliliters	milliliters	0.0338	fluid ounces
gallons	3.7854	liters	liters	0.26417	gallons
gallons	0.00378	cubic meters			
cubic feet	0.028317	cubic meters	cubic meters	35.315	cubic feet
cubic yards	0.76455	cubic meters	cubic meters	1.038	cubic yards
Weight					
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.45360	kilograms	kilograms	2.2046	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons
Temperature					
Fahrenheit	Subtract 32 then multiply by 5/9ths	Celsius	Celsius	Multiply by 9/5ths then add 32	Fahrenheit

Table MC-2
Names and Symbols for Units of Measure

Length

Symbol	Name
cm	centimeter
ft	foot
in	inch
km	kilometer
m	meter
mi	mile
mm	millimeter
μm	micrometer

Numerical Relationships

Symbol	Meaning
$<$	less than
$\leq$	less than or equal to
$>$	greater than
$\geq$	greater than or equal to
2σ	two standard deviations

Volumes and Concentrations

Symbol	Name
cm^3	cubic centimeter
ft^3	cubic foot
gal	gallon
in^3	cubic inches
L	liter
m^3	cubic meter
mL	milliliter
ppb	parts per billion
ppm	parts per million
yd^3	cubic yard

Rate

Symbol	Name
cm^3/s	cubic meters per second
ft^3/s	cubic feet per second
ft^3/min	cubic feet per minute
gpm	gallons per minute
km/h	kilometers per hour
mi/h	miles per hour

Sound

Symbol	Name
dB	decibel
dBA	A-weighted decibel

Area

Symbol	Name
ac	acre
cm^2	square centimeter
ft^2	square foot
ha	hectare
in^2	square inch
km^2	square kilometer
mi^2	square mile

Mass

Symbol	Name
g	gram
kg	kilogram
mg	milligram
μg	microgram
ng	nanogram
lb	pound
ton	metric ton (1E+6 g)

Temperature

Symbol	Name
°C	degrees Centigrade
°F	degrees Fahrenheit
°K	degrees Kelvin

Many metric measurements presented include prefixes that denote a multiplication factor that is applied to the base standard (e.g., 1 kilometer = 1,000 meters). Table MC-3 presents these metric prefixes.

Table MC-3
Metric Prefixes

Prefix	Symbol	Multiplication Factor
exa	E	1 000 000 000 000 000 000 = 10^{18}
peta	P	1 000 000 000 000 000 = 10^{15}
tera	T	1 000 000 000 000 = 10^{12}
giga	G	1 000 000 000 = 10^{9}
mega	M	1 000 000 = 10^{6}
kilo	k	1 000 = 10^{3}
hecto	h	100 = 10^{2}
deka	da	10 = 10^{1}
deci	d	0.1 = 10^{-1}
centi	c	0.01 = 10^{-2}
milli	m	0.001 = 10^{-3}
micro	μ	0.000 001 = 10^{-6}
nano	n	0.000 000 001 = 10^{-9}
pico	p	0.000 000 000 001 = 10^{-12}
femto	f	0.000 000 000 000 001 = 10^{-15}
atto	a	0.000 000 000 000 000 001 = 10^{-18}

RADIOACTIVITY UNITS

Sections of SEIS-II deal with levels of radioactivity that might be found in various environmental media. Radioactivity is a property; the amount of a radioactive material is usually expressed as "activity" in curies (Ci) (Table MC-4). The curie is the basic unit used to describe the amount of substance present, and concentrations are generally expressed in terms of curies per unit mass or volume. One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Disintegrations generally include emissions of alpha or beta particles, gamma radiation, or combinations of both.

RADIATION DOSE UNITS

The amount of ionizing radiation energy received by a living organism is expressed in terms of radiation dose. Radiation dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of rem (Table MC-5). Rem is a term that relates ionizing radiation and biological effect or risk. A dose of 1 millirem (0.001 rem) has a biological effect similar to the dose received from about a 1-day exposure to natural background radiation. A list of the radionuclides discussed in this document and their half-lives is included in the section entitled Select Radionuclides.

CHEMICAL ELEMENTS

A list of chemical elements, chemical constituents, and their nomenclature is presented in Table MC-6.

Table MC-4
Names and Symbols for Units of Radioactivity

Radioactivity	
Symbol	Name
Ci	curie
cpm	counts per minute
mCi	millicurie (1E-3 Ci)
μCi	microcurie (1E-6 Ci)
nCi	nanocurie (1E-9 Ci)
pCi	picocurie (1E-12 Ci)

Table MC-5
Names and Symbols for Units of Radiation Dose

Radiation Dose	
Symbol	Name
mrad	millirad (1E-3 rad)
mrem	millirem (1E-3 rem)

Table MC-6
Elemental and Chemical Constituent Nomenclature

Symbol	Constituents	Symbol	Constituents
Ag	silver	Pa	protactinium
Al	aluminum	Pb	lead
B	boron	Pu	plutonium
Be	beryllium	SF_6	sulfur hexafluoride
CO	carbon monoxide	Si	silicon
CO_2	carbon dioxide	SO_2	sulfur dioxide
Cu	copper	Ta	tantalum
F^-	fluoride	Th	thorium
Fe	iron	Ti	titanium
MgO	magnesium oxide	U	uranium
N	nitrogen	UO_2	uranium oxide
Ni	nickel	V	vanadium
NO_2-	nitrite	W	tungsten
NO_3-	nitrate	Zn	zinc

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SELECT RADIONUCLIDES

HALF-LIVES OF SELECT RADIONUCLIDES

Symbol	Radionuclide	Half-Life
Ac-225	Actinium-225	10.0 days
Ac-227	Actinium-227	21.8 years
Ac-228	Actinium-228	6.13 hours
Ag-109m	Silver-109m	39.8 seconds
Am-241	Americium-241	432 years
Am-243	Americium-243	7,380 years
At-217	Astatine-217	32 milliseconds
Ba-137m	Barium-137m	2.55 minutes
B-7	Boron-7	53.4 days
Bi-210	Bismuth-210	5.01 days
Bi-212	Bismuth-212	60.6 minutes
Bi-213	Bismuth-213	46 minutes
Bi-214	Bismuth-214	19.8 minutes
Bk-249	Berkelium-249	311 days
C-14	Carbon-14	5,730 years
Cd-109	Cadmium-109	453 days
Ce-144	Cerium-144	284 days
Cf-249	Californium-249	352 years
Cf-252	Californium-252	2.64 years
Cm-242	Curium-242	163 days
Cm-243	Curium-243	28.5 years
Cm-244	Curium-244	18.1 years
Cm-245	Curium-245	8,500 years
Cm-246	Curium-246	4,730 years
Cm-247	Curium-247	1.56E+7 years
Cm-248	Curium-248	3.39 E+5 years
Co-60	Cobalt-60	5.27 years
Cs-134	Cesium-134	2.06 years
Cs-137	Cesium-137	30.0 years
Eu-152	Europium-152	13.33 years
Eu-154	Europium-154	8.8 years
Eu-155	Europium-155	4.96 years
Fr-221	Francium-221	4.8 minutes
H-3	Hydrogen-3	12.4 years
I-129	Iodine-129	1.57E+7 years
Kr-85	Krypton-85	10.7 years
Ni-63	Nickel-63	96 years
Np-237	Neptunium-237	2.14E+6 years
Np-239	Neptunium-239	2.35 days
Pa-231	Protactinium-231	3.28E+4 years
Pa-233	Protactinium-233	27.0 days

Symbol	Radionuclide	Half-Life
Pa-234m	Protactinium-234m	1.17 minutes
Pb-209	Lead-209	3.25 hours
Pb-210	Lead-210	22.3 years
Pb-212	Lead-212	10.6 hours
Pb-214	Lead-214	26.8 minutes
Pm-147	Promethium-147	2.62 years
Po-210	Polonium-210	138 days
Po-212	Polonium-212	0.305 microseconds
Po-213	Polonium-213	4.2 microseconds
Po-214	Polonium-214	164 microseconds
Po-216	Polonium-216	0.15 microseconds
Po-218	Polonium-218	3.05 minutes
Pr-144	Praseodymium-144	17.3 minutes
Pu-236	Plutonium-236	2.85 years
Pu-238	Plutonium-238	87.7 years
Pu-239	Plutonium-239	24,065 years
Pu-240	Plutonium-240	6,537 years
Pu-241	Plutonium-241	14.4 years
Pu-242	Plutonium-242	3.76E+5 years
Pu-244	Plutonium-244	8.26E+7 years
Ra-223	Radium-223	11.4 days
Ra-226	Radium-226	1,600 years
Ra-228	Radium-228	5.75 years
Rn-220	Radon-220	55.6 seconds
Rn-222	Radon-222	3.82 days
Ru-106	Ruthenium-106	368 days
Sb-125	Antimony-125	2.77 years
Sm-151	Samarium-151	90 years
Sr-90	Strontium-90	29.1years
Tc-99	Technetium-99	2.13E+5 years
Th-228	Thorium-228	1.91 years
Th-230	Thorium-230	7.7E+4 years
Th-232	Thorium-232	1.41E+10 years
U-232	Uranium-232	72 years
U-233	Uranium-233	1.59E+5 years
U-234	Uranium-234	2.45E+5 years
U-235	Uranium-235	7.04E+8 years
U-236	Uranium-236	2.34E+7 years
U-238	Uranium-238	4.47E+9 years
Y-90	Yttrium-90	64.0 hours
Zr-95	Zirconium-95	64.0 days

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SUMMARY

SUMMARY

INTRODUCTION

The U.S. Department of Energy (hereafter the Department or DOE) needs to dispose of transuranic (TRU) waste generated by its past, present, and future activities in a manner that protects public health and the environment. In previous National Environmental Policy Act (NEPA) documents, the Department examined alternatives to repository disposal at the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. In this document, the *Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II), the Department assesses whether to dispose of TRU waste at WIPP. This document also assesses reasonable options for transportation and other activities associated with disposal, as well as reasonable alternatives concerning quantities, sources, and treatment of TRU waste before disposal.

TRU waste is contaminated with alpha-emitting radionuclides that are heavier than uranium (i.e., their atomic numbers are greater than that of uranium) and that have half-lives longer than 20 years at concentrations greater than 100 nanocuries per gram of waste. Key radionuclides found in TRU waste include americium-241 and several isotopes of plutonium (Pu-238, Pu-239, Pu-240, and Pu-241). Since 1970, DOE has segregated TRU waste from other radioactive waste and stored it in a manner that allows it to be retrieved. TRU waste that would be emplaced at WIPP resulted primarily from the following: (1) nuclear weapons development and manufacturing, (2) plutonium recovery, (3) defense research and development, (4) environmental restoration and decontamination and decommissioning, (5) waste management, and (6) testing at facilities that are under DOE contract.

TRU waste exists in a variety of forms ranging from unprocessed laboratory trash, such as tools, glassware, and gloves, to solidified sludges from wastewater treatment. TRU waste is classified, for handling purposes, as contact-handled (CH) TRU waste or remote-handled (RH) TRU waste depending on the radiation dose rate at the surface of the waste container. In addition, about 60 percent of TRU waste is classified as TRU mixed waste because it also contains hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). A major component of TRU mixed waste is metallic lead, which is present primarily in the form of glovebox parts and lead-lined gloves or aprons. Some TRU mixed waste contains traces of organic solvents such as methylene chloride and carbon tetrachloride, both common cleaning agents. Some TRU mixed waste also is commingled with polychlorinated biphenyls (PCB).

A 1981 Record of Decision (ROD), based on the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS), documented DOE's initial decision to proceed with the phased development of WIPP at a site near Carlsbad, New Mexico. In 1990, following construction of most of the WIPP facilities, the Department prepared the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) to update the environmental record established in the FEIS. In the SEIS-I ROD, published in the Federal Register on June 22, 1990, DOE chose the Proposed Action Alternative, which was to continue with a phased approach to WIPP by testing TRU waste underground at the facility. DOE subsequently decided to perform the tests in aboveground laboratories instead of at WIPP.

The 1990 ROD committed the Department to prepare SEIS-II prior to a decision to dispose of waste at WIPP and determined that the scope of SEIS-II would include an analysis of the long-term

performance of WIPP in light of new information obtained since 1990. It also stated that DOE would study the potential impacts to generator, storage, and treatment sites throughout the country of disposing of waste at WIPP. Since SEIS-I and its ROD, the Department has analyzed options for consolidating, regionalizing, or decentralizing TRU waste processing and handling among its facilities, the results of which are included in the *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS) published in August 1995. Where appropriate, SEIS-II incorporates and expands upon these analyses.

Although SEIS-II incorporates by reference, and where appropriate, updates and adjusts information from the Draft WM PEIS, the potential actions analyzed in SEIS-II are not connected to the potential actions analyzed in the Draft WM PEIS. To further explain, the WM PEIS evaluates alternative configurations for managing five types of waste, including TRU waste, that are at DOE sites or are otherwise under DOE's control or responsibility. The alternative configurations range from managing the wastes where they are presently located to transporting them to one centralized site for management. The WM PEIS evaluates trends in various impacts as alternative configurations become more or less centralized. The WM PEIS postulates three generic types of treatment for TRU waste, in order to analyze the impacts of treating and storing TRU waste under the various alternative configurations. These generic treatments allow DOE, in the WM PEIS, to compare the relative impacts of centralized, regionalized, and decentralized treatment and storage. To reduce the potential impacts of storing untreated wastes, DOE must decide, pursuant to the WM PEIS, the most cost-effective and environmentally preferable configuration to treat and store TRU waste, regardless of whether the Department decides to dispose of this waste at WIPP.

In addition to TRU waste, the WM PEIS analyzes four other types of waste: high level waste, low level waste, low level mixed waste, and hazardous waste. These wastes would not be disposed of at WIPP, and management of these wastes is unrelated to, and outside the scope and purpose of, the SEIS-II.

SEIS-II, in contrast, is the third in a series of staged NEPA reviews and focuses on WIPP disposal of TRU waste. waste. SEIS-II analyzes impacts and alternatives for disposal at WIPP, transportation to WIPP, and associated activities not addressed in, and not within the scope of, the Draft WM PEIS. SEIS-II involves additional and different workers, time frames, transportation modes, alternatives and affected environments. Decisions associated with whether to dispose of TRU waste at WIPP can and should be made regardless of any decisions made pursuant to the WM PEIS. Furthermore, decisions for TRU waste disposal are far removed from decisions on management of the other types of waste analyzed in the WM PEIS. Decisions concerning WIPP pursuant to SEIS-II will not automatically trigger or prejudice decisions for high-level waste, low-level waste, hazardous waste, and low-level mixed waste that may be made pursuant to the WM PEIS. As such, SEIS-II and the WM PEIS have different purposes, meet different needs, and are independently justified.[1]

Since SEIS-I and its ROD, several events have occurred that could affect the treatment and handling of TRU waste and a decision concerning its disposal at WIPP. In 1992, Congress passed the WIPP Land Withdrawal Act (LWA) (Public Law 102-579), which reserves the 16-section area surrounding the WIPP site for the construction, experimentation, operation, repair, maintenance, disposal, shutdown, monitoring, and decommissioning of WIPP. The LWA also limits the

[1] The analyses presented in the WM PEIS and SEIS-II are more understandable and useful for decision making and for informing the public than they would be if combined in a single, less focused document.

radiation permitted at WIPP and the total volume of TRU waste permitted to be disposed of. Also in 1992, Congress passed the Federal Facility Compliance Act (FFCAct), requiring DOE to prepare plans for developing treatment capacities and technologies for mixed waste, including TRU mixed waste. In 1996, Congress passed the National Defense Authorization Act for Fiscal Year 1997 (Public Law 104-201), which amended the LWA. Among other things, Public Law 104-201 provides that RCRA land disposal restrictions do not apply to waste disposed of at WIPP. Other changes since SEIS-I include regulatory and statutory changes, changes in the TRU waste inventory, and the development of new hydrologic and geologic information that may help DOE understand WIPP and its ability to isolate waste. SEIS-II takes into account all of the changed circumstances that might affect potential environmental impacts of TRU waste disposal at WIPP and closure of the WIPP facility once operations cease.

SEIS-II is an integrated part of DOE's overall decision regarding the disposal of TRU waste at WIPP. SEIS-II has been timed to take advantage of information presented in prior documents and to inform current and future planning efforts. The relationship between SEIS-II and major planning and compliance documents is as follows:

- *Compliance Certification Application:* Conceptual models and computer codes used for performance assessment calculations in the Compliance Certification Application were used in SEIS-II to assess the long-term ability of WIPP to isolate radioactive waste from the accessible environment.[1] (This application, has been submitted in draft form and will be finalized in October 1996.)

- *RCRA Part B Permit Application (submitted in April 1996):* This application provides background information regarding DOE proposals for operating WIPP and is, therefore, one of the foundations on which assumptions in SEIS-II are based.

- *Final Draft No-Migration Variance Petition (submitted in June 1996):* This document, submitted to the U.S. Environmental Protection Agency (EPA) and published on June 14, 1996, is a petition to receive a variance from the RCRA Land Disposal Restrictions (LDR) on the basis that the migration of hazardous constituents would not exceed health-based levels at the disposal unit boundary. (Such a variance is no longer required pursuant to the National Defense Authorization Act for Fiscal Year 1997.) The document also provides background information on the long-term ability of WIPP to isolate hazardous waste and has been summarized and incorporated by reference throughout SEIS-II.

- *WIPP Safety Analysis Report (published in November 1995):* This document provides analyses of routine exposures and potential accident scenarios, which have been incorporated in SEIS-II.

- *Transuranic Waste Baseline Inventory Report, Revision 2 (BIR-2) (published in December 1995):* This report provides the waste volumes, hazardous constituent inventories, and most of the radionuclide data used by DOE in its regulatory compliance applications. It is used as the basis for the SEIS-II waste inventories. SEIS-II supplements the radionuclide inventory with data from the Integrated Data Base (IDB). The

[1] The EPA Compliance Certification Criteria (40 CFR Part 194) are currently being challenged in court.

supplemented radionuclide data used for SEIS-II analyses incorporates most of the changes in radionuclide inventories that were later adopted in Revision 3 of BIR (see discussion below).

- *Transuranic Waste Baseline Inventory Report, Revision 3 (BIR-3) (published in June 1996):* This report, which DOE used for the WIPP Draft Compliance Certification Application, includes information pertaining to waste that is currently eligible for disposal at WIPP under existing laws. BIR-3 waste volumes and hazardous constituent inventories are unchanged from BIR-2. The radionuclide inventories at some sites are changed slightly in BIR-3. As pointed out above, SEIS-II supplements the BIR-2 radionuclide inventories with data from the IDB so that the adjusted radionuclide inventories used for SEIS-II analyses are comparable to BIR-3 inventories.[1] BIR-3 also includes added information on complexing agents, nitrates, sulfates, phosphates, and cement which are relevant to WIPP's long-term ability to contain TRU waste. The information on complexing agents, nitrates, sulfates, phosphates, and cement is incorporated into the parameters used in the SEIS-II analysis of long-term performance.

- *Comprehensive Disposal Recommendations (in preparation, schedule uncertain):* This report will recommend disposal options and the timetables for disposal of all TRU waste under DOE control, including waste that exceeds current capacity limits for WIPP and waste types (such as nondefense and commercial TRU waste), which cannot be emplaced at WIPP under current law. SEIS-II includes alternatives that examine the impacts of disposing of the entire DOE TRU waste inventory at WIPP.

- *Decommissioning and Post-Decommissioning Plan (scheduled for publication in 1997):* This plan will discuss the decommissioning of WIPP following its closure and what will happen to the WIPP facilities and property following decommissioning. SEIS-II considers decommissioning and post-decommissioning in its discussion.

The Proposed Action, three action alternatives, two no action alternatives, and the subalternatives considered in SEIS-II comprise a wide range of options on which the Department can base the following decisions:

- Whether to open WIPP for disposal of TRU waste or continue to maintain the waste in storage. The two no action alternatives examine the impacts of not opening WIPP.

- Which types and quantities of TRU waste should be disposed of at WIPP or continued in storage. SEIS-II includes analysis of CH-TRU waste, RH-TRU waste, post-1970 defense TRU waste, nondefense TRU waste, commercial TRU waste, pre-1970 buried TRU waste, and PCB-commingled TRU waste. The alternatives differ in the waste types and quantities involved. For all alternatives, SEIS-II analyzes CH-TRU and RH-TRU waste, both separately and together.

[1] DOE has evaluated the differences in the two inventories and found that use of BIR-3 inventories instead of the adjusted BIR-2 inventories would lead to equivalent or slightly lower impacts; any differences in impacts would not be discernible after rounding.

- Which level of waste treatment should be required for disposal or storage. The three action alternatives differ in the treatment involved, as do the two no action alternatives. [1]

- Whether to transport TRU waste primarily by truck or by rail and truck (using rail as much as practical). Three transportation options (truck, commercial rail and truck, and dedicated rail and truck) are assessed for all alternatives except two: the Proposed Action, for which transportation by truck is proposed, and No Action Alternative 2, for which there would be no transportation. Decisions based on SEIS-II may combine the transportation options.

Portions of two or more of the alternatives analyzed in SEIS-II may be combined and used by the Department. For this reason, results in SEIS-II are presented separately for RH-TRU waste and CH-TRU waste, by each transportation option, and by inventory type. The impacts of numerous combinations of the options can be calculated by summing the impacts of the various analyses.

BACKGROUND

WIPP is located in Eddy County in southeastern New Mexico. It is about 26 miles (42 kilometers) east of Carlsbad, New Mexico, in an area known as Los Medaños ("the dunes"), a relatively flat, sparsely inhabited plateau with little surface water. The land is mainly used for grazing; other uses include potash mining and oil and gas exploration and development.

WIPP was authorized by Public Law 96-164 to provide a research and development facility for demonstrating the safe disposal of radioactive waste produced by national defense activities. DOE's decision to proceed with WIPP at the southeastern New Mexico site followed a thorough NEPA review and was announced in the 1981 ROD. The decision called for the phased development of WIPP for the disposal of TRU waste generated since 1970. The WIPP facility was originally designed to dispose of approximately 175,600 cubic meters (6.2 million cubic feet) of CH-TRU waste and 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste in a 40-hectare (100-acre) excavated repository.

The major construction activities at WIPP have been completed. Surface facilities have been constructed, including the Waste Handling Building where TRU waste would be received, inspected, and moved to the waste handling shaft for transfer underground. The constructed underground facilities include four shafts, the waste disposal area, an experimental area (now closed), an equipment and maintenance area, and connecting tunnels. These underground facilities were excavated in the Salado Formation, 655 meters (2,150 feet) beneath the land surface. DOE also has excavated the first panel, which consists of seven disposal rooms. This panel is currently ready to receive waste.

DESCRIPTION OF THE ALTERNATIVES

SEIS-II analyzes six alternatives: the Proposed Action; Action Alternatives 1, 2, and 3; and No Action Alternatives 1 and 2. Action Alternatives 1, 2, and 3, and No Action Alternative 1 have one or more subalternatives and transportation options. These alternatives, subalternatives, and options vary in the waste inventory considered, the type of treatment, and the type of transportation.

[1] DOE may decide, for site-specific reasons, to further treat TRU waste below the level required in the planning-basis Waste Acceptance Criteria (WAC), even under those alternatives that propose treatment to the WAC. For example, DOE may incinerate or thermally treat TRU waste at some sites, even though thermal treatment is not required by the current planning-basis WAC. Such decisions would be based on site-specific NEPA reviews.

Inventories and Treatment

For SEIS-II, the Basic Inventory includes the defense TRU waste that has been placed in retrievable storage since 1970 and the defense TRU waste that would continue to be generated through 2033 from plutonium stabilization and management activities, environmental restoration, decontamination and decommissioning, waste management, and defense testing and research. Table S-1 shows the TRU waste that comprises this inventory and its location. Such defense TRU waste can be disposed of at WIPP under the LWA, up to the capacity limits in the LWA and the Compliance and Certification Agreement with New Mexico (C&C Agreement).

Table S-1
Basic Inventory TRU Waste Volumes[a]

	Stored (1995) (cubic meters)		Estimated Total through 2022[b] (cubic meters)		Projected Total through 2033 (cubic meters)	
Site[c]	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	12,000	200	46,000	22,000	57,000	29,000
Los Alamos National Laboratory (LANL)	11,000	94	18,000	190	21,000	230
Idaho National Engineering Laboratory (INEL)	28,000	220	28,000	220	28,000	220
Argonne National Laboratory - West (ANL-W)	7	19	750	1,300	1,000	1,700
Argonne National Laboratory - East (ANL-E)	25	---[d]	150	---	200	---
Savannah River Site (SRS)	2,900	---	9,600	---	12,000	---
Rocky Flats Environmental Technology Site (RFETS)	4,900	---	9,300	---	11,000	---
Oak Ridge National Laboratory (ORNL)	1,300	2,500	1,600	2,900	1,700	3,100
Lawrence Livermore National Laboratory (LLNL)	230	---	940	---	1,200	---
Nevada Test Site (NTS)	620	---	630	---	630	---
Mound Plant (Mound)	300	---	300	---	300	---
Bettis Atomic Power Laboratory (Bettis)	---	---	120	7	170	9
Sandia National Laboratories - Albuquerque (SNL)	7	---	14	---	17	---
Paducah Gaseous Diffusion Plant (PGDP)	---	---	6	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	3	---
Energy Technology Engineering Center (ETEC)	2	6	2	7	2	7
University of Missouri Research Reactor (U of Mo)	1	---	1	---	1	---
Pantex Plant (Pantex)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	---	---	1	---	1	---
Teledyne Brown Engineering (TBE)	1	---	1	---	1	---
Battelle Columbus Laboratories (BCL)	---	580	---	580	---	580
Totals	**62,000**	**3,600**	**116,000**	**27,000**	**135,000**	**35,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites. The thermal treatment, though, is not necessarily for PCB-commingled waste. The Basic Inventory is waste that resulted from defense activities and that was placed in retrievable storage pursuant to the Atomic Energy Commission policy of 1970 and TRU waste reasonably expected to be generated by these ongoing activities. Volumes have been rounded. Actual totals may differ due to rounding. Projected totals have not been adjusted in anticipation of disposal.

[b] Post-1970 defense TRU waste volumes through 2022 are estimated in BIR-2.

[c] The Proposed Action, described in Chapter 3, is based on operation of WIPP for 35 years through 2033. Total includes TRU waste to be generated for 35 years.

[d] Sites in boldface were included in SEIS-I. INEL and ANL-W are located near each other and are counted as a single site in SEIS-II; however, ANL-W is listed separately to indicate its contribution to the inventory.

[e] Dashes indicate no TRU waste.

DOE also owns or controls other TRU waste including nondefense, commercial, and previously disposed of waste. The previously disposed of waste includes waste buried prior to the 1970 decision to keep TRU waste in a retrievable manner. In SEIS-II, this waste is referred to as the Additional Inventory. The Additional Inventory also includes all nondefense or commercial waste that DOE believes will be generated through 2033. Currently, the commercial and nondefense waste is not permitted at WIPP under the terms of the LWA. Table S-2 presents the volumes and locations of this waste. Included in the Additional Inventory is a small amount of waste (720 cubic meters or 25,430 cubic feet) that has been commingled with PCBs. The impacts of disposing of this small amount of waste are estimated in SEIS-II for alternatives that include thermal treatment of waste.

When both the Basic Inventory and Additional Inventory are considered together, the combined volume is called the Total Inventory in SEIS-II. The Total Inventory, therefore, includes all of the TRU waste that DOE is currently responsible for and all DOE TRU waste anticipated through 2033. The waste in the Total Inventory is stored or would be generated at the 24 sites shown on Figure S-1.

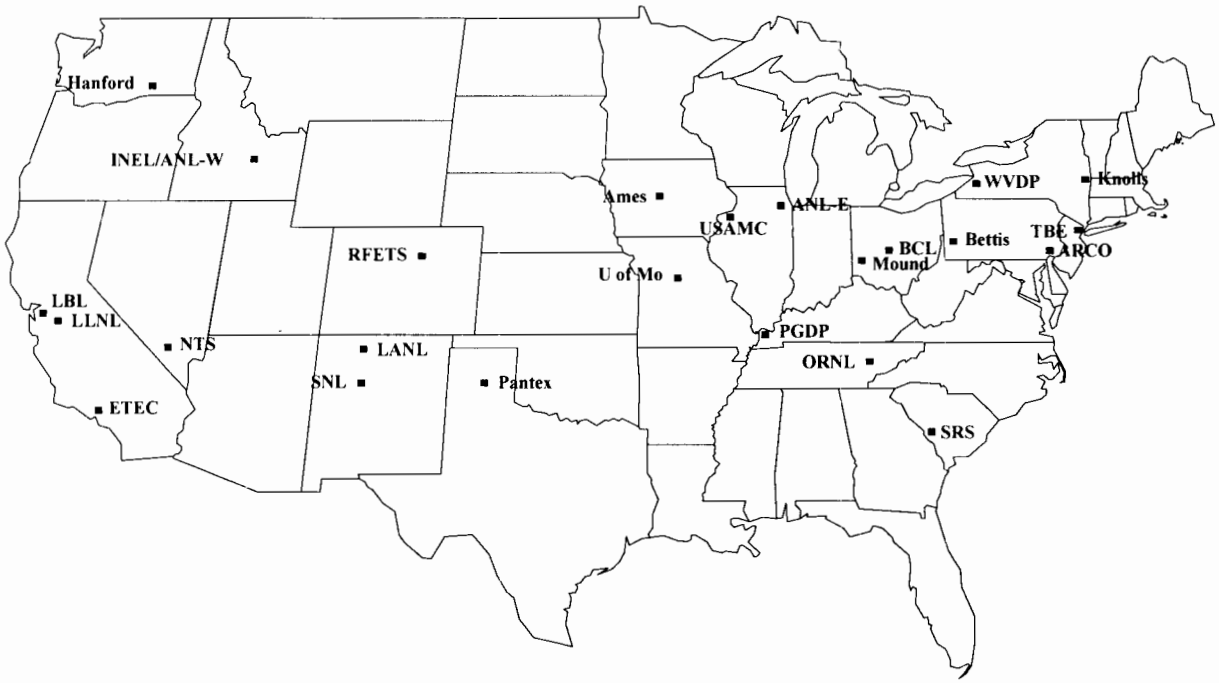


Figure S-1
Approximate Location of the SEIS-II TRU Waste Sites

The waste volumes presented in Tables S-1 and S-2 are not the volumes that would be emplaced at WIPP under the Proposed Action or the action alternatives. The emplaced volumes would be different due to three factors. First, the LWA and agreements with the State of New Mexico limit the volumes of CH-TRU and RH-TRU defense waste permitted at WIPP. These limits establish the maximum defense TRU waste that would be disposed of at WIPP under the Proposed Action. The action alternatives consider larger volumes and additional types of waste, and may require amendment of the LWA and/or the C&C Agreement to be fully implemented. Second, packaging

Table S-2
Additional Inventory TRU Waste Volumes [a, b, c]

Site[d]	PCB-Commingled (cubic meters)		Commercial/Nondefense (cubic meters)		Previously Disposed of (cubic meters)		Total (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	240	---[e]	---	---	63,000	1,000	63,000	1,000
Los Alamos National Laboratory (LANL)	---	---	---	---	14,000	120	14,000	120
Idaho National Engineering Laboratory (INEL)	460	---	---	---	57,000	440	57,000	440
Savannah River Site (SRS)	---	---	---	---	4,900	---	4,900	---
Oak Ridge National Laboratory (ORNL)	---	---	5	---	61	120	66	120
Mound Plant (Mound)	19	---	---	---	---	---	19	---
Sandia National Laboratories - Albuquerque (SNL)	---	---	---	---	1	---	1	---
ARCO Medical Products Company (ARCO)	---	---	1	---	---	---	1	---
Knolls Atomic Power Laboratory (Knolls)	---	---	---	81	---	---	---	81
Lawrence Berkeley Laboratory (LBL)	---	---	2	---	---	---	2	---
West Valley Demonstration Project (WVDP)	---	---	190	370	---	1,400	190	1,700
Totals	**720**	**---**	**200**	**450**	**138,000**	**3,100**	**139,000**	**3,500**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites. The thermal treatment, though, is not necessarily for PCB-commingled waste. The Additional Inventory includes PCB-commingled TRU waste, commercial TRU waste, nondefense TRU waste , and TRU waste disposed of prior to the Atomic Energy Commission policy of 1970.

[b] The volume of TRU waste includes the 1995 existing and projected waste through 2033.

[c] Actual totals may differ due to rounding.

[d] Sites in boldface also store post-1970 defense TRU waste, see Table S-1. The remaining four sites currently have no post-1970 defense TRU waste.

[e] Dashes indicate no TRU waste.

waste for emplacement changes its volume; in particular, the volume of RH-TRU waste increases by 43 percent once the volume of its containers is considered. Finally, three different methods of treating the waste are considered in SEIS-II alternatives; two of these treatment methods (thermal treatment and shred and grout treatment) substantially change the volume of waste.

The volume of TRU waste that would be emplaced under each SEIS-II alternative, after adjustment for the three factors described above, are presented in Figures S-2 and S-3 and in Table S-3.

Table S-3
TRU Waste Post-Treatment (Emplacement) Volumes
(in cubic meters)

Proposed Action		Action Alternative 1		Action Alternative 2 (All Subalternatives)	
CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste
168,500	7,080	281,000	55,000	107,000	19,000
Action Alternative 3		No Action Alternative 1 (Both Subalternatives)		No Action Alternative 2	
CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste
334,000	66,000	107,000	19,000	135,000	35,000

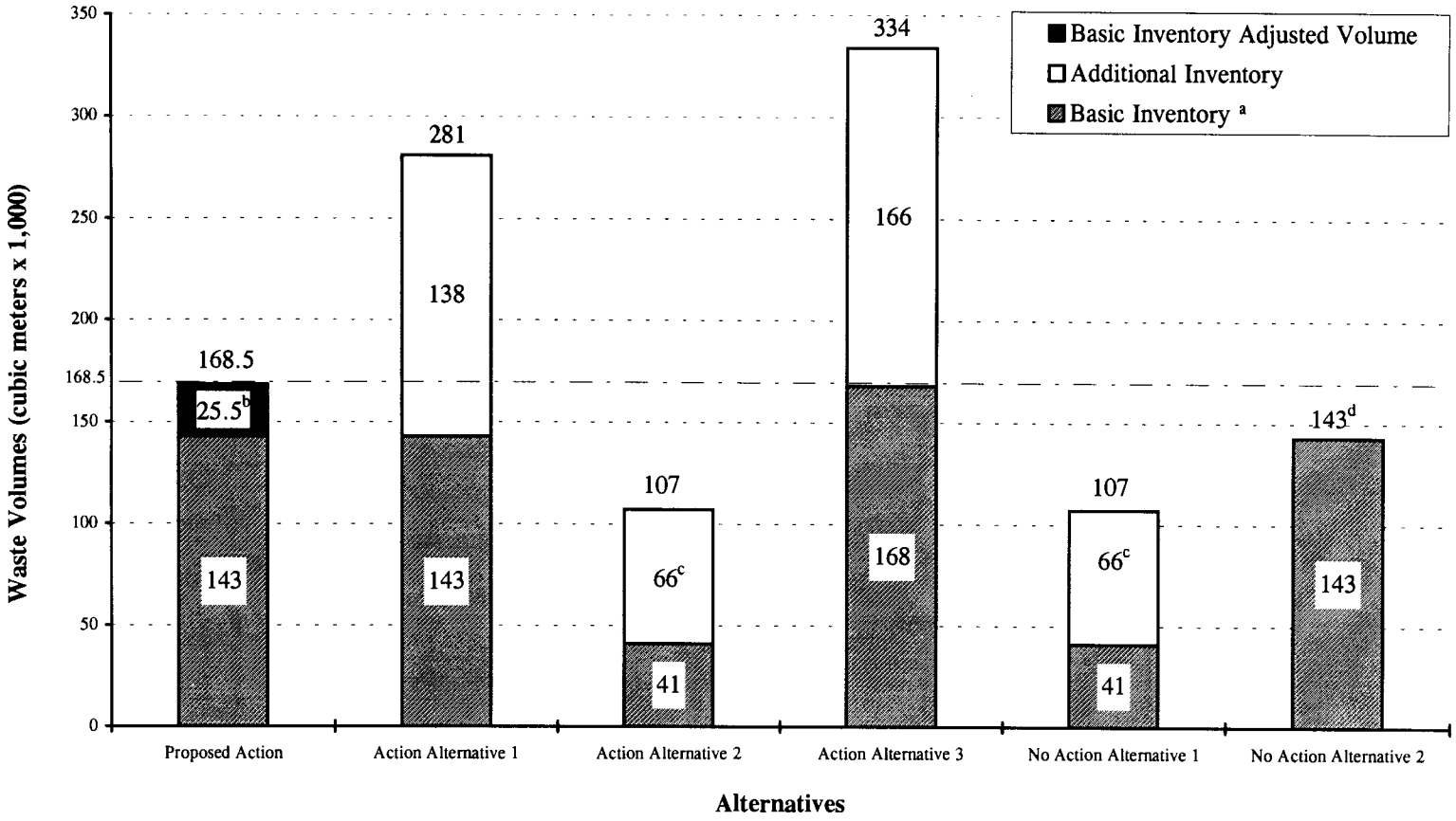
The three treatment methods considered in SEIS-II are treatment to meet the current planning-basis WIPP Waste Acceptance Criteria (WAC), treatment by a shred and grout process, and treatment by a thermal process to meet the RCRA LDRs. Each is discussed below:

- The treatment method that changes the waste volume the least is treatment to meet the planning-basis WAC. The WAC are based on the level of treatment that is currently required by applicable regulations (such as U.S. Department of Transportation regulations) or current DOE policies. The current planning-basis WAC, the fifth revision of the WAC, was the basis for SEIS-II analyses. The WAC may be revised again in the future. In particular, if DOE decides to treat the waste using a shred and grout or thermal process, using that process would become part of the WAC.

- One SEIS-II action alternative (Action Alternative 3) considers treatment of the waste by shredding it and sealing it in grout. This method of treatment reduces the gas generation potential of the waste; however, it also substantially increases the volume of waste.

- Another method of treating waste uses a thermal process that would substantially condense the waste and remove many of the hazardous constituents of the TRU mixed waste. Waste commingled with PCBs could be treated using a thermal process and then disposed of at WIPP. Action Alternatives 2A, 2B, and 2C and No Action Alternatives 1A and 1B consider treatment using a thermal process.

The Draft WM PEIS analyzed the impacts of centralizing, regionalizing, and decentralizing treatment of TRU waste at various sites throughout the nation, using the three treatment methods being considered in SEIS-II. For the Draft WM PEIS alternatives, three basic consolidation



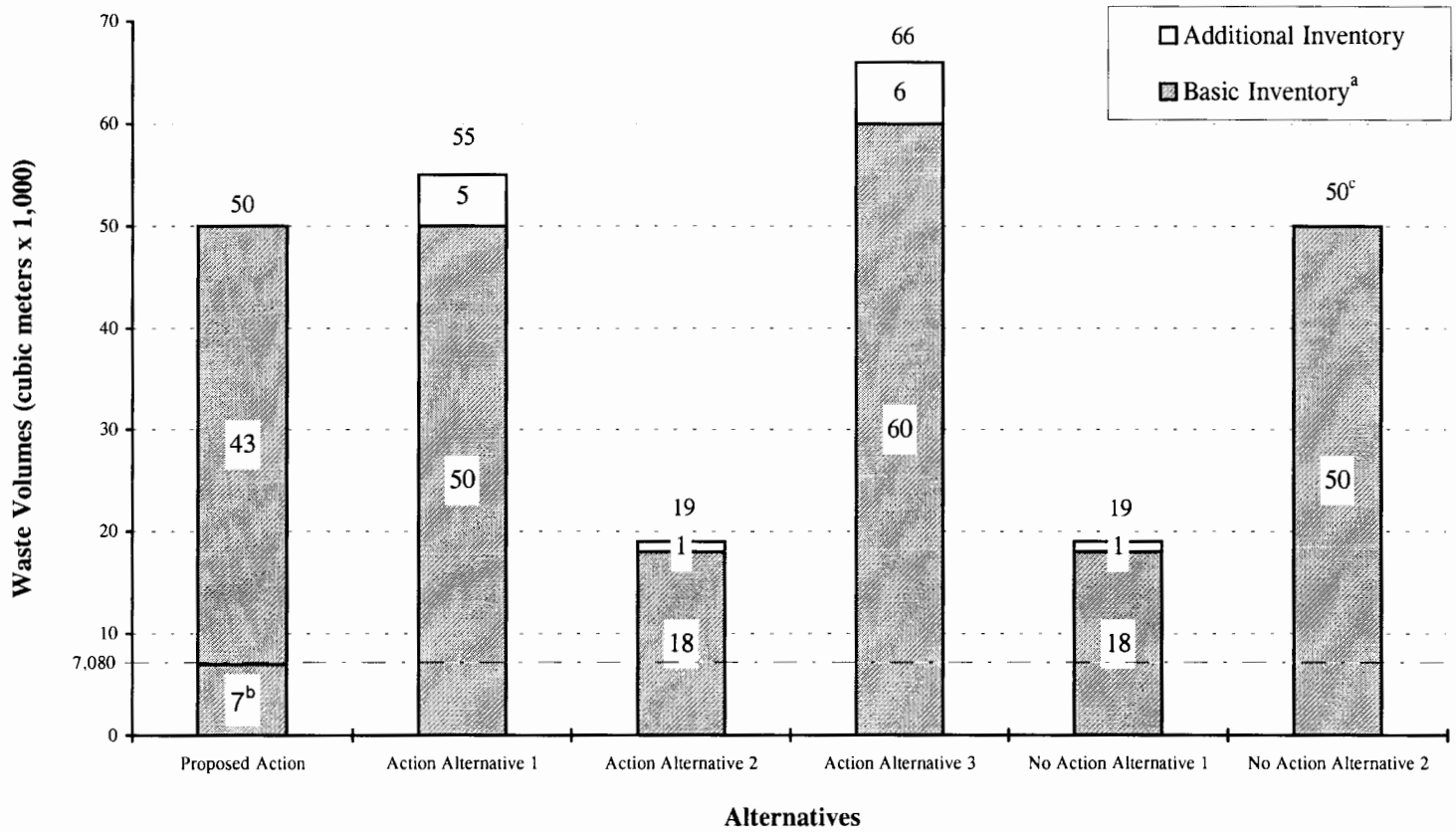
[a] The Basic Inventory consists of post-1970 and newly generated defense waste. The Basic Inventory for all alternatives has the same radionuclide inventory.

[b] The CH-TRU waste Basic Inventory is adjusted from approximately 143,000 cubic meters to 168,500 cubic meters in order to evaluate the total volume of CH-TRU waste allowable at WIPP under current laws and agreements.

[c] Includes TRU waste commingled with PCBs.

[d] Only 73,000 cubic meters of newly generated defense waste would be treated. Existing stored waste would not be treated.

Figure S-2
CH-TRU Post-Treatment Waste Volumes by Alternative



[a] The Basic Inventory consists of post-1970 and newly generated defense waste. The Basic Inventory for all alternatives has the same radionuclide inventory.

[b] Only 7,080 cubic meters of the Basic Inventory (14 percent of the Basic RH-TRU inventory) was evaluated for WIPP disposal under the Proposed Action because of the WIPP disposal limit established under the C&C with the State of New Mexico. The excess RH-TRU waste would be treated to WAC and stored at non-WIPP treatment sites.

[c] Only 32,000 cubic meters of newly generated defense waste would be treated. Existing stored waste would not be treated.

Figure S-3
RH-TRU Post-Treatment Waste Volumes by Alternative

options were considered. For its Decentralized Alternative, the Draft WM PEIS estimated impacts of treating TRU waste where it is currently stored or where it would be generated. For its Regionalized Alternatives, the Draft WM PEIS analyzed the impacts of transporting waste to regional sites and treating it there. For its Centralized Alternative, the Draft WM PEIS considered shipping the CH-TRU waste to WIPP and treating it at a new treatment facility that would be built there and shipping the RH-TRU waste to two centralized RH-TRU waste treatment facilities. SEIS-II uses and builds upon the Draft WM PEIS analyses of potential waste treatment locations under these consolidation schemes. Each SEIS-II alternative is based on a similar alternative presented in the Draft WM PEIS. (See Appendix B for details on each WM PEIS alternative; see Chapter 3 for details on which SEIS-II alternative matches which Draft WM PEIS alternative.)

Proposed Action: Basic Inventory, Treat to WAC, Dispose of at WIPP

Under the Proposed Action, DOE would continue with the phased development of WIPP by disposing of post-1970 defense TRU waste in the WIPP repository. The Proposed Action is the Department's preferred alternative because it meets DOE's purpose and need for action to the extent allowable by law and current agreements. This action would dispose of 175,600 cubic meters (6.2 million cubic feet) of the Basic Inventory. Because only 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste can be disposed of at WIPP (under current laws and agreements), additional RH-TRU waste in this inventory (43,000 cubic meters [1.5 million cubic feet]) would be treated to the planning-basis WAC and kept in storage until another disposal solution is found. DOE anticipates that it would complete actions necessary to allow commencement of disposal of TRU waste at WIPP by November 30, 1997, as encouraged by Public Law 104-201. For the purposes of analysis in this SEIS-II, disposal is assumed to begin by 1998.

Twenty of the 24 sites in Figure S-1 would generate the TRU waste or currently have it in storage. All such waste would first be treated and packaged at the 20 sites, as necessary to meet WAC. The waste then would be consolidated at the 10 sites with the largest volumes of waste to await shipment.

Under the Proposed Action, only trucks would transport the TRU waste. CH-TRU waste would be transported in TRUPACT-IIs, which have been certified by the U.S. Nuclear Regulatory Commission (NRC). RH-TRU waste would be transported in RH-72B casks, which are in the NRC certification process. Potentially, some CH-TRU waste may be transported in "half packs," which are smaller TRUPACT-IIs that are being designed by DOE and have yet to be certified by NRC. The currently designated truck routes are somewhat different from those presented in SEIS-I, in part because states have modified the state-designated routes; however, the routes comply with U.S. Department of Transportation requirements and use the Interstate Highway System or state-designated alternate routes.

Each truck transporting CH-TRU waste would carry as many as three TRUPACT-IIs, containing a total load of up to 42 55-gallon drums or six standard waste boxes. At WIPP, the waste packages would be removed from the transport pallets and stacked three high in the disposal panels. Each disposal panel would accommodate approximately 81,000 55-gallon drums, equivalent to 16,700 cubic meters (590,000 cubic feet) of CH-TRU waste. Each truck transporting RH-TRU waste would carry one RH-72B cask within which would be a single canister containing up to three 55-gallon drums of RH-TRU waste. The process of filling the disposal rooms with RH-TRU waste would be coordinated between the generator-storage sites and WIPP, because the RH-TRU waste would be placed in the walls of the panel rooms and in the walls of the access tunnels before they

were filled with CH-TRU waste. Sacks of magnesium oxide backfill would be placed around the emplaced CH-TRU waste as an engineered barrier. Each disposal panel would accommodate 714 canisters, equivalent to 635 cubic meters (22,950 cubic feet) of RH-TRU waste. On average, personnel at WIPP could unload and dispose of the waste in about 50 TRUPACT-IIs and about eight RH-72B casks per week.

Under the Proposed Action, WIPP would receive and dispose of the Basic Inventory for 35 years. DOE would close the repository when all waste disposal areas were filled or when WIPP would achieve a capacity of 175,600 cubic meters (6.2 million cubic feet) of TRU waste. Final facility closure would include the placement of a repository sealing system. As explained in more detail in the RCRA Part B Permit Application, the planned repository sealing system would consist of natural and engineered barriers within the WIPP repository that would prevent water from entering it and impede the gases or brines from migrating out. The seal design for the repository shafts would use materials that may include highly compacted crushed salt, clay, concrete, and asphalt. The salt, when consolidated over time, would preclude the downward flow of groundwater into the repository and the upward movement of brine or gas that may be contaminated. The Department would decommission the WIPP site in a manner that would allow for safe, permanent disposition of surface and underground facilities and that would be consistent with then-applicable regulations. Little or no contamination of facilities would be expected. Useable equipment would be removed and surface facilities would be dismantled. A berm would be constructed around the perimeter of the site. DOE would restore the areas occupied by the salt pile (generated during excavation of the repository) and surface facilities, and, if necessary, any of the area overlying the repository, although surface disturbance of this area would be minimal. This decommissioning period is anticipated to take up to 10 years. There are no changes since SEIS-I to the proposed long-term controls for WIPP, which would include active controls, monitoring, and permanent markers or signs and other passive controls.

Action Alternative 1: Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP

Under Action Alternative 1, DOE would dispose of TRU waste at WIPP. The Total Inventory would include both the Basic Inventory and the Additional Inventory, but it would not include TRU waste commingled with PCBs. This alternative would dispose of 336,000 cubic meters (11.9 million cubic feet) of treated TRU waste, nearly twice the volume of the Proposed Action. All 24 sites shown on Figure S-1 currently store or would generate this waste over a 35-year period. The waste would be treated to WAC at the sites where it is located or would be generated. It would then be consolidated at the 10 sites with the largest volumes until its disposal. This storage is referred to as lag storage throughout SEIS-II.

For the purposes of analysis, waste disposal at WIPP is assumed to begin in 1998; disposal would extend over a 160-year period, until 2158. The 160-year period has been anticipated due to the greater volume of waste and the anticipated throughput rate anticipated for WIPP. Shipment of waste to WIPP would have three options: by truck only, by regular rail and truck (from those sites that do not have rail access), or by dedicated rail and truck. The impacts of each of these transportation options are estimated in SEIS-II.

CONSERVATISM OF TRU WASTE INVENTORY ESTIMATES

TRU waste inventory estimates, as used throughout the SEIS-II analyses, embody many conservative assumptions to ensure bounding analyses of maximum, reasonably foreseeable impacts. The following reflect some of the conservative assumptions.

- The latest estimates of TRU waste volumes (i.e., those which are reported in the *Transuranic Waste Baseline Inventory Report*, Revision 2 [BIR-2]) include projections that may overestimate TRU waste volumes. For instance, in both the Basic Inventory and the Additional Inventory, volume estimates include projections of waste yet to be generated. Though the Department's TRU waste generation due to defense activities has decreased because of a change in the nation's nuclear weapons needs, the projections of future waste also include waste anticipated by such activities as decontamination and decommissioning. These activities, which would include cleaning and disassembling facilities, can generate a great deal of TRU waste, but whether that waste will actually be generated and whether it will be CH-TRU or RH-TRU waste is uncertain. For the purposes of analyses, SEIS-II has used the estimates included in BIR-2, which were provided by each facility based upon current plans.

- The Additional Inventory includes estimates of TRU waste produced prior to 1970 and believed to have been disposed of in trenches at some of the sites. Since DOE's definition of TRU waste has changed and some of the buried waste would probably be classified as low-level waste under current definitions, the amount of this waste that is actually TRU waste is unknown. For the purposes of analyses, all of this waste, as estimated in BIR-2, is considered part of the Additional Inventory and the effects of its disposal at WIPP are assessed in the SEIS-II action alternatives. SEIS-II analyzes 141,000 cubic meters (5 million cubic feet) of TRU waste that has been previously disposed of. Currently, though, DOE estimates that only 80,000 cubic meters (2,830,000 cubic feet) of this waste would be excavated.

- The Agreement for Consultation and Cooperation (C&C Agreement) between the State of New Mexico and DOE limits the amount of RH-TRU waste allowable at WIPP to 7,080 cubic meters (250,000 cubic feet). The Department's Proposed Action proposes disposing of this amount of RH-TRU waste. The actual amount of RH-TRU waste disposed of may, however, be as low as 4,300 cubic meters (150,000 cubic feet). This is because current plans call for disposing of this waste in the walls of WIPP panel rooms before emplacement of CH-TRU waste in the rooms. At startup, delays in preparing the RH-TRU waste for shipment are anticipated, which would result in the emplacement of some CH-TRU waste before RH-TRU waste is ready for WIPP. To ensure that SEIS-II disposal analyses are conservative, the analyses for the Proposed Action were conducted as if the full 7,080 cubic meters of RH-TRU waste would be emplaced.

- Application of the LWA and the C&C Agreement would limit the amount of CH-TRU waste allowable under the Proposed Action to 168,500 cubic meters (5,950,000 cubic feet), but only 143,000 cubic meters (5,050,000 cubic feet) is estimated to be in the Basic Inventory. Still, because of the potential for excavation of previously disposed of waste (which would then be classified as newly generated) and the potential for treatment of alpha-emitting low level waste that could convert currently non-TRU waste forms into TRU waste (as discussed in the cumulative impacts analysis), SEIS-II analyses consider the effects of filling WIPP to its allowable capacity.

- BIR-2 estimates indicate that about 60 percent of the nation's TRU waste is TRU mixed waste, with constituents that would be hazardous. Under some of the alternatives considered for SEIS-II, this waste would be treated to remove many of the hazardous constituents that make it mixed waste and would be reduced in volume. For the purpose of analysis of impacts from treatment, it was assumed that 100 percent of the TRU waste would be treated as TRU mixed waste and reduced in volume.

- While the LWA and C&C Agreement include limits on the volume of TRU waste that can be emplaced, there is considerable uncertainty concerning how much of a container's volume is made up of TRU waste and how much is void space. Many of the containers would include a great deal of void space, particularly for RH-TRU waste; the actual volume of waste in a drum or cask, therefore, may be much less than the volume of the drum or cask. For the purposes of analyses in SEIS-II, the volume of the drum or cask is used.

While volume changes to the TRU waste inventory could reduce or increase the effects calculated in SEIS-II, the best estimates available have been used and conservative assumptions have been incorporated to ensure that the results would actually be less than those presented. A box similar to this one, entitled "Factors to Consider in Combining Alternatives" (presented in Chapter 5), explains in more detail how the results would change as inventory volumes change.

Action Alternative 2: Total Inventory (Including PCB-Commingled Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP

Under Action Alternative 2, DOE would dispose of TRU waste at WIPP after thermally treating it to meet the LDRs. This alternative would dispose of 126,000 cubic meters (4.5 million cubic feet) of TRU waste and would include both the Basic Inventory and the Additional Inventory. TRU waste containing PCB-commingled material is included in the inventory for this alternative. All 24 sites shown in Figure S-1 would either generate this waste over a 35-year period or currently have it in storage.

For Action Alternative 2, three different consolidation and treatment subalternatives are considered[1]:

- Action Alternative 2A. DOE would treat CH-TRU waste at the Hanford Site (Hanford), Savannah River Site (SRS), Rocky Flats Environmental Technology Site (RFETS), Los Alamos National Laboratory (LANL), and Idaho National Engineering Laboratory/Argonne National Laboratory-West (INEL/ANL-W). RH-TRU waste would be treated at Hanford and Oak Ridge National Laboratory (ORNL).

- Action Alternative 2B. DOE would treat CH-TRU waste at Hanford, SRS, and INEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL.

- Action Alternative 2C. DOE would treat CH-TRU waste at WIPP. RH-TRU waste would be treated at Hanford and ORNL.

Waste treatment would begin in 2010, after the treatment facilities had been constructed, and would continue for 35 years. Waste disposal also would begin in 2010 and would continue over a 150-year period, until 2160. The 150-year period would be necessary because of the time needed to excavate the required waste panels. Between treatment and disposal of the waste, lag storage would be conducted at the treatment sites. Shipment of waste to WIPP would be by truck only, by regular rail and truck, or by dedicated rail and truck. The impacts of each of these transportation options are estimated in SEIS-II.

Action Alternative 3: Total Inventory (Except PCB-Commingled Waste), Treat by Shred and Grout, Dispose of at WIPP

Under Action Alternative 3, DOE would dispose of TRU waste at WIPP after treating it by a shred and grout process. This alternative would dispose of 400,000 cubic meters (14.1 million cubic feet) of TRU waste and would include both the Basic Inventory and the Additional Inventory. TRU waste containing PCB-commingled material is excluded from this alternative. All 24 sites shown in Figure S-1 would either generate this waste over a 35-year period or currently have it in storage. The CH-TRU waste would be treated at Hanford, LANL, RFETS, SRS, and INEL/ANL-W. The RH-TRU waste would be treated at Hanford and ORNL.

Waste treatment would begin in 2010, after the treatment facilities had been constructed and would continue for 35 years. Following treatment, lag storage would be conducted at the treatment sites. Waste disposal would begin in 2010 and would continue until 2200. The 190-year period is

[1] Decisions on whether and how waste treatment would be consolidated and the treatment locations would be made in the TRU waste Record of Decision for the WM PEIS.

anticipated due to the volume of waste and the anticipated throughput rate at WIPP. Shipment of waste to WIPP would be by truck only, by regular rail and truck, or by dedicated rail and truck. The impacts of each of these transportation options are estimated in SEIS-II.

No Action Alternative 1: Total Inventory (Including PCB-Commingled Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP

Under No Action Alternative 1, DOE would dismantle and close WIPP beginning in 1998. Closure of the facility would take 10 years. Under this alternative, DOE also would treat all DOE TRU waste by a thermal process to meet the LDRs and store it for an indefinite period at the treatment sites. About 126,000 cubic meters (4.5 million cubic feet) of TRU waste would be treated and stored; this includes both the Basic Inventory and the Additional Inventory and includes TRU waste commingled with PCBs. All 24 sites shown in Figure S-1 would either generate this waste over a 35-year period or currently have it in storage. Waste treatment would begin in 2010 after treatment facilities and newly engineered storage facilities had been constructed at the treatment sites. Two consolidation and treatment subalternatives are considered for No Action Alternative 1:

- No Action Alternative 1A. DOE would treat CH-TRU waste at Hanford, LANL, SRS, and INEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL. These sites would then store the waste indefinitely.

- No Action Alternative 1B. DOE would treat CH-TRU waste at Hanford, SRS, and INEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL. These sites would then store the waste indefinitely.

Shipment of waste to the treatment sites would be by truck only, by regular rail and truck, or by dedicated rail and truck. For the purpose of analyses, it was assumed that CH-TRU waste packaging (standard 55-gallon drums) would last 20 years; therefore, the waste would be overpacked at 20-year intervals. RH-TRU waste would not be repackaged because its specially designed containers would last much longer than 20 years.

No Action Alternative 2: Basic Inventory, Treat Newly Generated Waste to WAC, Store at Generator Sites, Dismantle WIPP

Under No Action Alternative 2, DOE would dismantle and close WIPP, leave existing TRU waste as it is, treat newly generated waste to meet WAC, and store all waste. This alternative would store 170,000 cubic meters (6 million cubic feet) of TRU waste. Twenty sites would either generate this waste over a 35-year period or currently have it in storage. Each site would be responsible for storage of its current and newly generated TRU waste. New facilities may be constructed if necessary, pursuant to future NEPA reviews, but the analyses consider storage only in existing facilities. There would be no planned shipment of waste to consolidation sites unless it was deemed necessary in the future to ensure the safe storage of TRU waste.

Table S-4 gives a tabular comparison of the major features of the Proposed Action and the alternatives.

Table S-4
Summary of WIPP SEIS-II Alternatives

Comparison Parameters	*Proposed Action:* Basic Inventory, Treat to WAC, Dispose of at WIPP	*Action Alternative 1:* Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP	*Action Alternative 2:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP	*Action Alternative 3:* Total Inventory (Except PCB-Commingled TRU Waste), Treat by Shred and Grout, Dispose of at WIPP	*No Action Alternative 1:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP	*No Action Alternative 2:* Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP [a]
Waste Type	Defense-related, post-1970 TRU waste in retrievable storage and newly generated through the year 2033 (Basic Inventory).	Basic Inventory plus other DOE-owned or controlled waste including non-defense, commercial, previously disposed of waste, and excluding PCB-commingled waste (Additional Inventory).	Basic Inventory plus Additional Inventory (including PCB-commingled waste).	Basic Inventory plus Additional Inventory (excluding PCB-commingled waste).	Basic Inventory plus Additional Inventory (including PCB-commingled waste).	Same as Proposed Action.
Post-Treatment Volume[b] to be Disposed of at WIPP, or Stored	CH-TRU: 168,500 m^3 (5,950,000 ft^3) RH-TRU: 7,080 m^3 (250,000 ft^3) Excess Waste RH-TRU 43,000 m^3 (1,500,000 ft^3)	CH-TRU: 281,000 m^3 (9,900,000 ft^3) RH-TRU: 55,000 m^3 (2,000,000 ft^3)	CH-TRU: 107,000 m^3 (3,800,000 ft^3) RH-TRU: 19,000 m^3 (690,000 ft^3)	CH-TRU: 334,000 m^3 (11,800,000 ft^3) RH-TRU: 66,000 m^3 (2,300,000 ft^3)	CH-TRU: 107,000 m^3 (3,800,000 ft^3) RH-TRU: 19,000 m^3 (690,000 ft^3)	CH-TRU: 135,000 m^3 (4,800,000 ft^3) RH-TRU: 35,000 m^3 (1,200,000 ft^3)
Waste Consolidation and Treatment Locations	20 sites total - WAC treatment of CH-TRU at the largest sites and store at 10 largest sites[c]. Ship to WIPP. - WAC treatment of RH-TRU at Hanford, INEL/ANL-W, ORNL, and LANL. Ship to WIPP.	24 sites total - Same as Proposed Action except two other sites (LBL, WVDP) consolidate and treat CH-TRU at Mound and Hanford.	24 sites total Action Alternative 2A - LDR treatment of CH-TRU at Hanford, INEL, LANL, SRS, and RFETS. - LDR treatment of RH-TRU at Hanford and ORNL. Action Alternative 2B - LDR treatment of CH-TRU at Hanford, INEL, and SRS. - LDR treatment of RH-TRU at Hanford and ORNL. Action Alternative 2C - LDR treatment of CH-TRU at WIPP. - LDR treatment of RH-TRU at Hanford and ORNL.	24 sites total - Shred and grout treatment of CH-TRU at Hanford, INEL, LANL, SRS, and RFETS. - Shred and grout RH-TRU at Hanford and ORNL.	24 sites total No Action Alternative 1A - LDR treatment of CH-TRU at Hanford, INEL, LANL, SRS, and RFETS. - LDR treatment of RH-TRU at Hanford and ORNL. No Action Alternative 1B - LDR treatment of CH-TRU at Hanford, INEL, and SRS. - LDR treatment of RH-TRU at Hanford and ORNL.	Minimal consolidation to ensure safe storage; however, no sites would ship to WIPP.
Waste Treatment	Treat to meet WAC.	Treat to meet WAC.	Thermal treatment to meet the LDRs (including PCB-commingled waste).	Treatment by shred and grout.	Thermal treatment to meet the LDRs (including PCB-commingled waste). Package every 20 years indefinitely.	Newly generated waste treated to WAC.

Table S-4
Summary of WIPP SEIS-II Alternatives—Continued

Comparison Parameters	*Proposed Action:* Basic Inventory, Treat to WAC, Dispose of at WIPP	*Action Alternative 1:* Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP	*Action Alternative 2:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP	*Action Alternative 3:* Total Inventory (Except PCB-Commingled TRU Waste), Treat by Shred and Grout, Dispose of at WIPP	*No Action Alternative 1:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP	*No Action Alternative 2:* Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP [a]
Transportation Mode	Truck only.	Three options: - Truck only - Maximum[d] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[d] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[d] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[d] commercial rail - Maximum dedicated rail	Truck only.
Disposal Operations	CH-TRU stacked in disposal rooms. RH-TRU placed in horizontal boreholes. RH-TRU disposal would start 6 years after CH-TRU and 7,080 m^3 (250,000 ft^3) of RH-TRU can be disposed of. 10 panel equivalents required at WIPP.[e]	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 68 panel equivalents required at WIPP.	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 75 panel equivalents required at WIPP.	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 71 panel equivalents required at WIPP.	No disposal. CH-TRU and RH-TRU would be in newly engineered, monitored storage at treatment sites.	No disposal. CH-TRU and RH-TRU continue to use existing storage.
WIPP Operations Time Frame	Receive and emplace waste beginning 1998 for 35 years. Decommissioning for 10 years and active institutional control for 100 years, ending in 2143.	Same as Proposed Action, lag storage for 125 years and disposal would be for 160 years, until 2158; active institutional control ending in 2268.	Waste disposal and thermal treatment to meet the LDRs would begin in 2010 after treatment facility construction. Lag storage for 115 years. Disposal would be for 150 years, until 2160. Decommissioning and active institutional control would be the same as the Proposed Action, ending in 2270.	Waste disposal and shred and grout treatment would begin in 2010 after treatment facility construction Lag storage for 155 years. Disposal would be for 190 years, until 2200. Decommissioning and active institutional control would be the same as the Proposed Action, ending in 2310.	Dismantle and close WIPP in 10 years. Thermal treatment to meet the LDRs would begin in 2010 after treatment facility construction. Package and manage indefinitely at treatment sites.	Dismantle and close WIPP. Sites generate waste for 35 years beginning in 1998. Storage at the generator-storage sites evaluated for 35 years, ending in 2033. Active institutional control at generator-storage sites until 2133.
WIPP Institutional Control Site Area	60 hectares (150 acres)	295 hectares (730 acres)	324 hectares (800 acres)	307 hectares (760 acres)	20 hectares (50 acres) (Only for 10 years during decommissioning)	20 hectares (50 acres) (Only for 10 years during decommissioning)

[a] New facilities may be constructed in the future pursuant to future NEPA review.
[b] These values correspond to the Post-Treatment Consolidated Volume and Post-Treatment Disposal Volume data in Tables 3-1 through 3-16; differences in the numbers are due to rounding. The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites.
[c] The 10 largest generator-storage sites are ANL-E, Hanford, INEL/ANL-W, LANL, LLNL, Mound, NTS, ORNL, RFETS, and SRS.
[d] Maximum rail is used to denote that 18 of the 24 sites have rail facilities nearby; the remaining sites would ship by truck. Areas and volumes have been rounded.
[e] Under the Proposed Action, the consequence analysis for RH-TRU waste is based on 7,080 cubic meters (250,000 cubic feet), the maximum disposal volume of RH-TRU waste that is allowable at WIPP under the Consultation and Cooperation Agreement. The disposal strategy is to emplace RH-TRU waste canisters in the panel room walls prior to stacking CH-TRU waste in the rooms. At startup, however, a lag in RH-TRU waste availability is anticipated that would result in only CH-TRU waste initially being disposed of. The actual amount of RH-TRU waste disposed of, therefore, may be as low as 4,300 cubic meters.

Alternatives Considered But Not Analyzed

SEIS-II does not include detailed analyses of several alternatives discussed during the public scoping process. These alternatives were not analyzed in detail because — depending on the alternative and as discussed in Chapter 3 — they are not technically viable, would not adequately or economically meet DOE's need to safely dispose of TRU waste in a timely manner, involve additional environmental and policy concerns that would need to be accommodated, or are otherwise unreasonable in the present context. The following alternatives were not analyzed in detail: transmutation, co-processing TRU waste with high-level waste and vitrifying it, disposal in space, underground detonation, subseabed disposal, deep borehole disposal, greater confinement (shallow borehole disposal), geologic repositories at sites other than WIPP, the use of developing technologies to neutralize or change the natural rate of radioactive decay, and alternative engineered barriers (in lieu of magnesium oxide backfill).

AFFECTED ENVIRONMENT AT WIPP

The environment that would be affected by activities described in SEIS-II is essentially the same as that presented in the FEIS in 1980 and SEIS-I in 1990. A few changes have occurred, though, and some new information is now available. The following sections discuss the more notable of these changes and the sources of some of the new information.

Land Use

Since SEIS-I, a multi-year research effort has been initiated to document the population and ecology of several species. Additional seeding of reclamation sites has been undertaken. A comprehensive WIPP archeological database has been created. Vegetation is now monitored for evidence of stress induced by climate and salt tailings. In 1994, DOE requested and was granted permission by the U.S. Bureau of Land Management to construct a short access road. Three plans have been published on emergency and facility security. Seven new wells have been installed to monitor water quality.

Air Quality

Since publication of SEIS-I, activities conducted at the WIPP site have had little effect on the air quality at the site. Two changes have occurred to air monitoring programs. In 1991, a volatile organic compound (VOC) monitoring program was established at WIPP after the EPA determined that migration of VOCs might be a concern in conjunction with the then-planned test phase at WIPP. On October 30, 1994, after DOE decided not to conduct underground experiments at WIPP and after DOE notified the EPA, monitoring of pollutant gases at the WIPP Ambient Air Monitoring Station was discontinued.

Geology and Hydrology

Additional studies and analyses have provided new information regarding geology and hydrology since publication of SEIS-I. Several examples are listed below:

- Extensive testing of the Salado Formation's salt beds and interbeds has confirmed their extremely low permeability.

- Recent test data have improved prediction of the pressures needed to fracture Salado interbeds.

- Refined modeling has suggested that elevated gas pressure may slow down or stop brine inflow, thereby slowing those processes that may generate gas in the repository.

- Recent geophysical surveys have indicated that pressurized brine occur in three or four discrete areas of the Castile Formation, which is located below the Salado.

- Three-dimensional modeling of groundwater flow in the Rustler Formation (which is above the Salado) has suggested that flow occurs vertically and horizontally in all units. Flow, though, is principally in the Culebra Dolomite.

Rare, Threatened, and Endangered Species

The threatened, endangered, candidate, and proposed species present in Eddy County, New Mexico, have changed since SEIS-I. In 1995, DOE obtained new lists from the U.S. Fish and Wildlife Service, the New Mexico Department of Game and Fish, and the New Mexico Energy, Minerals, and Natural Resources Department regarding the presence of federally threatened, endangered, and candidate species, state-listed rare and endangered animals, and state-listed rare and endangered plant species in Eddy County, New Mexico. Since SEIS-I, more than 60 new species have been added to these lists, none of which have been found within the WIPP land withdrawal boundary during preparation of DOE's biennial surveys. Currently, new surveys are being conducted to identify the occurrence of, or suitable habitats for, these species and other federally protected avian species. DOE will contact the Fish and Wildlife Service and state agencies concerning the results of these surveys, and will enter into formal consultation under the Endangered Species Act if required.

Cultural Resources Management

In 1994, a memorandum of understanding between DOE and the Department of the Interior transferred management responsibility for cultural resources at WIPP to DOE. Also, since publication of SEIS-I in 1990, additional cultural resource surveys have been conducted at WIPP. Based on inventory data, and assuming environmental homogeneity and a fairly even distribution of archaeological sites, DOE estimates that the WIPP site may contain about 99 archaeological sites and 153 locations where isolated artifacts. There are no known Native American sacred sites or burials in the Land Withdrawal Area.

Socioeconomics

Since publication in 1990 of SEIS-I, the following changes have occurred:

- Census information from the 1990 census has become available. Demographic characteristics in SEIS-II are based on 1990 U.S. Bureau of the Census information as well as more recent data.

- Recent employment and wage information has become available. SEIS-II uses 1994 information provided by the New Mexico Department of Labor and the University of New Mexico Bureau of Business and Economic Research.

Transportation

Some transportation routes have been modified since SEIS-I. The current primary truck transportation routes are indicated in Figure S-4.

AFFECTED ENVIRONMENTS AT THE TEN MAJOR GENERATOR-STORAGE SITES

The following sections briefly summarize the affected environments at the 10 major generator-storage sites. These 10 sites account for more than 99 percent of the Total Inventory.

Argonne National Laboratory-East (ANL-E)

ANL-E occupies 690 hectares (1,700 acres) in northeast Illinois, approximately 35 kilometers (22 miles) southwest of downtown Chicago, Illinois. Only 80 hectares (200 acres) of the site are used for DOE activities; the rest is devoted to forest and landscape areas.

ANL-E is located in a Class II Prevention of Significant Deterioration (PSD) air quality area. The site and the surrounding counties are classified by the EPA as severe nonattainment areas for the criteria pollutant ozone. ANL-E uses two principal aquifers for its water supply. The upper aquifer is about 60 meters (200 feet) thick and supplies potable water. The other aquifer is below the first, lying between 150 and 460 meters (500 and 1,500 feet) beneath the surface.

Species listed by the federal government as threatened or endangered are not known to reside on the ANL-E site. The site is frequented by one bird species listed as endangered by the state. As of 1994, with ANL-E completely surveyed, 43 prehistoric and six historic archeological properties had been discovered and recorded, and no sites had been listed with the National Register of Historic Places (NRHP) or designated as National Historic Landmarks. Three sites were potentially eligible for the NRHP.

The region of influence (ROI) accounts for 95.4 percent of the site's employee residential distribution. The ROI total population in 1992 was 6,568,800. Within the ROI, Whites comprise approximately 68.5 percent of the population, Blacks comprise 21.2 percent, and Hispanics comprise 12.1 percent. In 1989, about 9 percent of all families were below the poverty level. About 4,500 persons were employed at ANL-E.

The radiation dose from normal accident-free operations in 1994 would result in 3×10^{-3} latent cancer fatalities (LCF) to the population that resided within 80 kilometers (50 miles) of the site. The population within this area was 7,900,000. The annual dose from airborne radionuclides to the maximally exposed individual (MEI) during 1994 would result in an 8×10^{-7} percent chance of an LCF. The corresponding dose is far below the National Emission Standard for Hazardous Air Pollutants (NESHAP) limit.

Hanford Site (Hanford)

Hanford covers about 1,450 square kilometers (560 square miles) of the southeastern part of the State of Washington. The nearest city, Richland, Washington, borders the site on its southeast corner.

Air quality in the Hanford region is well within state and EPA standards for criteria pollutants, except that short-term particulate concentrations occasionally exceed the "particulate matter less

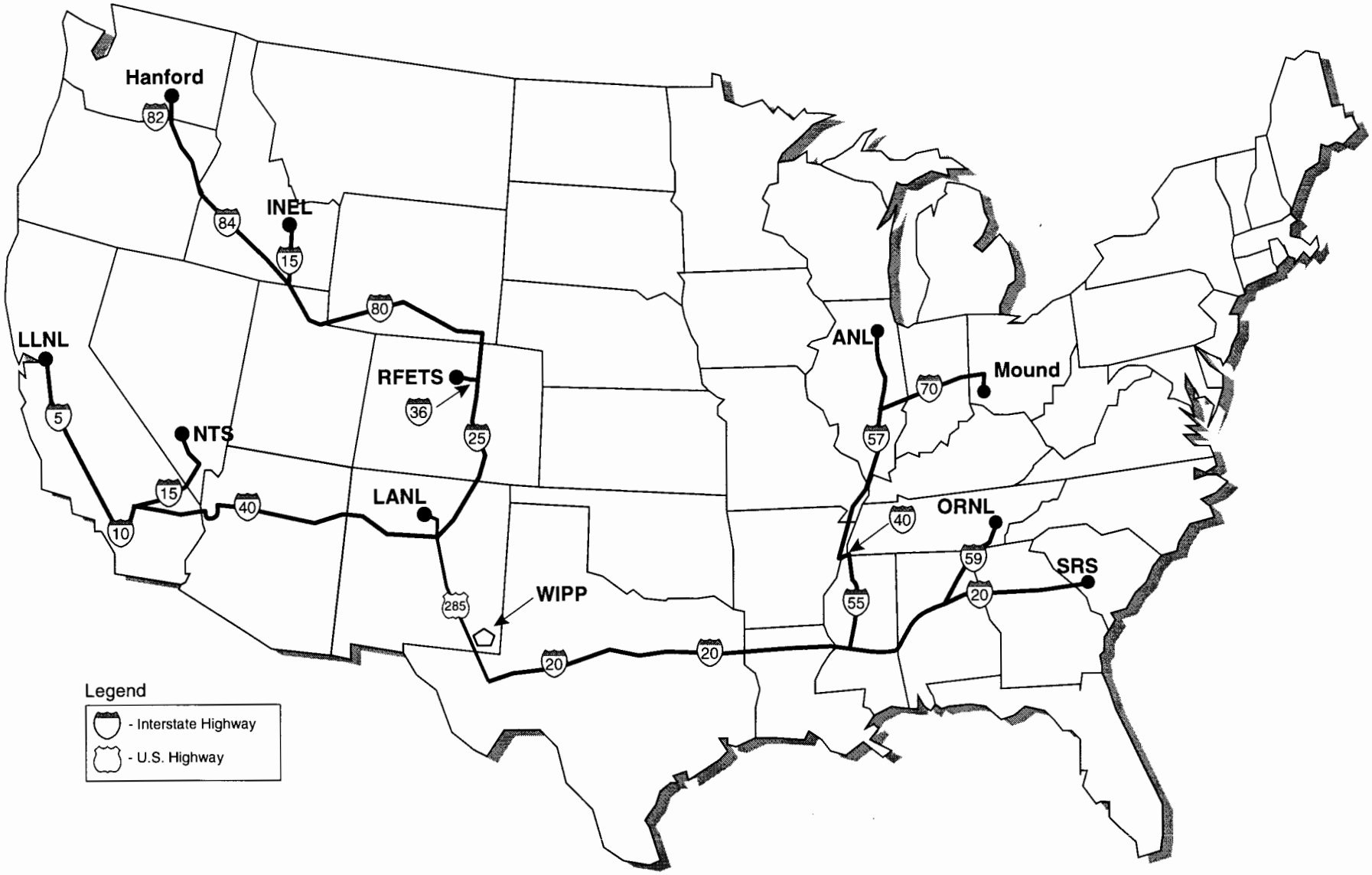


Figure S-4
Proposed TRU Waste Truck Transportation Routes from the 10 Major Generator-Storage Sites

than or equal to 10 micrometers in diameter" (PM_{10}) standard. The Columbia River passes through the northern part of Hanford and forms part of the eastern boundary. The water quality of the Columbia River is high, and the river contributes part of the water supply for the site and for nearby cities. Radiological monitoring shows low levels of radionuclides in the river, well below concentration guidelines established by EPA drinking water standards. Groundwater beneath the site is not used for human consumption or food production, except for one well used for drinking water. Levels of radionuclides have been detected in this well; however, the levels are well below EPA drinking water standards.

Six species of birds that have been listed as endangered or threatened by the state or federal government frequent the Hanford site. One mammal species found there is considered endangered by the state and four plant species are considered threatened or endangered. In addition, there are 12 other species of animals classified as species of concern by the state or federal government. As of 1992, 248 prehistoric archeological sites had been discovered and recorded, 48 of which are on the NRHP. In addition, 11 historic archeological sites and 11 other properties are also listed on the NRHP.

Hanford is included on the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priorities List.

The primary socioeconomic impact area is the tri-cities (Richland, Kennewick, and Pasco) and the counties of Franklin and Benton, in Washington State. The environmental justice ROI, which is the area within an 80-kilometer (50-mile) radius from the site, contains about 380,000 people. This ROI includes a 20 percent minority, 18 percent low-income, and 19 percent Hispanic population. The site employs about 14,200 people, accounting for almost 25 percent of the nonagricultural employment in Benton and Franklin Counties.

DOE has entered into agreements with the tribal governments representing the Yakama Indian Nation, Nez Perce Tribe, and the Confederated Tribes of the Unatilla Indian Reservation. These agreements pertain to the core environmental programs and the emergency preparedness and response program.

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 0.3 LCF. The population within this area was 380,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 3×10^{-7} percent chance of an LCF. The corresponding dose is far below the NESHAP limit.

Idaho National Engineering Laboratory (INEL)

INEL encompasses 230,000 hectares (568,000 acres) within five counties in southeastern Idaho. The site is about 44 kilometers (27 miles) west of Idaho Falls, Idaho. About 2 percent of the total INEL site area (4,600 hectares [11,400 acres]) is used for facilities and operations.

Concentrations of criteria pollutants at the site are below the National Ambient Air Quality Standards (NAAQS) and below state standards and PSD limits. INEL overlies the Snake River Plain Aquifer, a sole-source aquifer and the largest aquifer in Idaho. This aquifer is also the source of all water used at INEL. Inside the site boundary, several radionuclide concentrations have exceeded the EPA maximum contaminant limits for drinking water. Outside the site boundary, all contaminant levels measured have been below the EPA limits.

Two species considered endangered by the federal government and nine species considered species of concern potentially frequent the site. Also, INEL is included on the CERCLA National Priorities List.

The socioeconomic ROI is the seven-county area where more than 95 percent of INEL's approximately 6,400 employees reside. About 2.5 percent of the ROI population (104,654 in 1991) was Native American and 5.5 percent was Hispanic. Approximately 14 percent of this population was low-income.

DOE has entered into an agreement with the tribal governments representing the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation. This agreement is designed to enhance Tribal technical and scientific capability in the areas of environmental restoration, emergency preparedness and response, and management of cultural resources.

The annual radiation dose from normal operation of the site would have resulted in 0.2 LCF to the population residing within 80 kilometers (50 miles) of the site in 1994. The population within this area was 120,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 2×10^{-7} percent chance of an LCF. The corresponding dose is below the NESHAP limit.

Lawrence Livermore National Laboratory (LLNL)

LLNL includes the Livermore site, the adjoining Sandia National Laboratories, California (SNL-CA) site and the LLNL experimental test site (Site 300). The Livermore site is approximately 64 kilometers (40 miles) east of San Francisco, California, and about 5 kilometers (3 miles) east of Livermore, California.

The Livermore site is in the San Francisco Bay Area Interstate Air Quality Control Region. This region has been classified as a nonattainment area for two criteria pollutants: carbon monoxide (CO) and ozone (O_3). Site 300 is located within the San Joaquin Valley Unified Air Pollution Control District. This area is classified as a nonattainment area for O_3 and PM_{10}.

All three sites lie within Seismic Zone 4. The San Andreas fault system, the Sur-Nacimiento fault system, and the Coast Range thrust fault system are the major fault systems in the area. These major regional faults along with local faults are potential sources of ground motion at LLNL. In January 1980, an earthquake sequence on a local fault produced two earthquakes of magnitudes 5.5 and 5.6. These earthquakes caused structural damage at the Livermore and SNL-CA sites. Larger earthquakes on more distant faults, such as the San Andreas, do not substantially affect the hazard estimation for LLNL.

LLNL is investigating and identifying characteristics of groundwater contamination at Site 300. Several plumes of VOCs and tritium have been identified in shallow and deeper bedrock aquifers in this area and several adjacent off-site areas. LLNL is working with the EPA and the State of California to remediate these plumes. LLNL is included on the CERCLA National Priorities List.

Fifty-nine species considered by the federal or state government to be threatened or endangered or that have other special status are found on and in the vicinity of the Livermore site. Ten of these species have been observed on the site, including the bald eagle. Since 1974, several archaeological investigations have taken place at the Livermore site and Site 300. No prehistoric

sites have ever been located at the Livermore site. Cultural resource investigations at Site 300 have resulted in the discovery of seven prehistoric sites, 21 historic sites, and one site with elements of each.

Four counties comprise the socioeconomic ROI in which 97.2 percent of the approximately 7,850 Livermore site and Site 300 employees reside. In 1990, the population in the ROI was 2,952,000. This population was predominately White (69 percent). Approximately 8.4 percent of the families were living below the poverty level in 1989.

The annual radiation dose during normal operations in 1994 would have resulted in 9×10^{-3} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 6,300,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 3×10^{-6} percent chance of an LCF. The corresponding dose is far below the NESHAP limit.

Los Alamos National Laboratory (LANL)

LANL is located in north-central New Mexico, 97 kilometers (60 miles) north-northeast of Albuquerque, New Mexico, and 40 kilometers (25 miles) northwest of Santa Fe, New Mexico. The 11,300-hectare (28,000-acre) LANL site and adjacent communities are situated on the Pajarito Plateau.

LANL and its surrounding counties are considered attainment areas with respect to applicable NAAQS. All surface water drainages and groundwater from the Pajarito Plateau flows toward the Rio Grande. Groundwater in the LANL area occurs in four modes: shallow alluvium in canyons, perched water, the unsaturated zone between the surface and the main aquifer, and the main aquifer. LANL and the nearby communities are entirely dependent on groundwater for their water supply. The primary, secondary, and radiochemical groundwater quality, as measured from wells and springs in the main aquifer, are below DOE-derived concentration guides and the New Mexico standards applicable to a DOE drinking water system.

Thirty-four federal- or state-listed threatened, endangered, or other special status species may be found in the vicinity of LANL. Five of these species have been observed at LANL. Approximately 75 percent of LANL has been inventoried for cultural resources. More than 1,000 prehistoric sites have been recorded, and approximately 95 percent of these sites are considered eligible or potentially eligible for inclusion on the NRHP. More than 40 historic resources have been recorded at LANL, and about 90 percent of the resources are considered eligible or potentially eligible for the NRHP, based on their association with the broad historic theme of the Manhattan Project and initial nuclear production.

Three counties comprise the socioeconomic ROI in which 94.7 percent of LANL's 9,700 employees reside. In 1990, the ROI population was 152,300. The population in the ROI is predominately White (79.8 percent) and 12.1 percent of the families are below the poverty level.

DOE has entered into an agreement with Tribal governments representing the Pueblos of Santa Clara, Cochiti, Jemez, and San Ildefonso. This agreement is designed to build Tribal technical and scientific capability in environmental restoration and waste management and to assist the Tribes in participating in DOE decision making.

The radiation dose from normal operations in 1994 would result 2 x 10^{-3} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 220,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 4 x 10^{-4} percent chance of an LCF. The corresponding dose is below the NESHAP limit.

Mound Plant (Mound)

Mound is located in west-central Ohio within the city limits of Miamisburg, Ohio, about 16 kilometers (10 miles) south-southwest of Dayton, Ohio. Mound occupies about 124 hectares (306 acres) and is situated on the highlands overlooking the Great Miami River.

The Air Quality Control Region comprising the facility has been classified as attainment of the NAAQS for nitrogen dioxide (NO_2,), sulfur dioxide (SO_2,), and lead. However, Montgomery County has been classified as nonattainment for O_3 and total suspended particulates. The major aquifer in the area, the Buried Valley Aquifer (also called the Great Miami Aquifer), is the major source of the area's potable water. Typically, groundwater occurs 6 to 8 meters (20 to 25 feet) below ground surface in the valley. There has been minor contamination of the groundwater by Mound activities. Tritium and plutonium have been detected in the Miamisburg water supply at levels far below regulatory limits. Some VOCs in on-site groundwater exceed EPA levels; however, off-site concentrations are far lower and none exceed EPA levels.

The site lies within the range of one federally-listed bat species and contains a single individual of a state-listed endangered plant species. The only historic landmark in the vicinity of the site is the Miamisburg Mound, an ancient mound located 120 meters (390 feet) east-southeast of the site. It is believed to be a burial place of a member of the Adena culture of Mound Builders which inhabited the Ohio region in prehistoric times. The site itself does not contain any properties listed or eligible for the NRHP.

Miamisburg is largely residential, with limited regular rail and industrial development. The 1990 population of the city was 17,770. The facility employs about 1,200 people, the majority of whom live either in Miamisburg or in immediately adjacent areas.

The radiation dose from normal operations in 1994 would have resulted in 1 x 10^{-3} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 3 million. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 2 x 10^{-6} percent chance of an LCF. The corresponding dose is far below the NESHAP limit.

Nevada Test Site (NTS)

NTS occupies 3,500 square kilometers (1,350 square miles) of desert valley and Great Basin mountain terrain in southern Nevada, 105 kilometers (65 miles) northwest of Las Vegas, Nevada. NTS is designated as an attainment or unclassified area with respect to all applicable NAAQS. Since promulgation of regulations, no PSD permits have been required for any emissions source at NTS. There are no continuously flowing streams at NTS. The only permanent on-site water bodies are springs and ponds associated with wastewater disposal. NTS has three general water-bearing units, and all are classified as Class IIA or Class IIB aquifers. Groundwater is the only source of drinking water in the NTS area. Only three locations evidenced detectable tritium levels on a consistent basis. In all three cases, the tritium activity has been less than 2 percent of the primary maximum contaminant limit for tritium (20,000 picocuries per liter).

The desert tortoise is the only known species at NTS that is on federal endangered species lists. Approximately 6 percent of NTS has been inventoried for cultural resources, and more than 1,200 prehistoric sites have been found and recorded. Many of these sites may be eligible for listing on the NRHP.

Two counties comprise the economic ROI; 97 percent of the 1,600 NTS employees live within these two counties. The ROI population totaled 865,144 in 1992. The population in the ROI is predominately White (81.5 percent), and in 1989, 7.5 percent of the population was below the poverty level.

DOE has entered into two separate agreements with the Consolidated Group of Tribes and Organizations, which is composed of 17 tribes representing three ethnic groups (Western Shoshone, Owens Valley Paiute, and Southern Paiute) with cultural or historic ties to NTS. These agreements were intended to foster a government-to-government relationship and to encourage involvement in programs associated with NTS operations.

The radiation dose from normal operations in 1994 would result in 0.3 LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 33,000 that year. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 8×10^{-6} percent chance of an LCF. The corresponding dose is below the NESHAP limit.

Oak Ridge National Laboratory (ORNL)

ORNL is part of the Oak Ridge Reservation (ORR), which is located about 32 kilometers (20 miles) west of Knoxville, Tennessee, in the rolling terrain between the Cumberland Mountains and Great Smoky Mountains.

As of 1991, the area within the Air Quality Control Region was designated as an attainment area with respect to all NAAQS for criteria pollutants.

Substantial cleanup activities are required both on-site and off-site. Background groundwater quality is generally good in the near surface aquifer zones and poor in the bedrock aquifer due to high total dissolved solids. The contaminated sites include past waste disposal sites, waste storage tanks, spill sites, and contaminated inactive facilities. ORR is included on the CERCLA National Priorities List.

There are 88 federal- and state-listed threatened, endangered, and other special status species that have been identified on or in the vicinity of ORR. More than 20 cultural resource surveys have been conducted on ORR. Over 45 prehistoric sites have been identified and recorded. One site has been included in the NRHP, and several more are considered potentially eligible. More than 240 historic resources have been identified and recorded, and 50 of those sites may be eligible for the NRHP. The Graphite Reactor, located on the site, is a National Historic Landmark.

Four counties comprise the economic ROI; about 92 percent of ORR employees live in these four counties. The 1990 population of this ROI was about 489,000. Minorities comprised 8.4 percent of this population, and 10.6 percent of this population was below the poverty level.

The radiation dose from normal operations in 1994 would result in 2×10^{-2} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 940,000.

The annual dose from airborne radionuclides to the MEI during 1994 would result in a 9×10^{-5} percent chance of an LCF. The corresponding dose is below the NESHAP limit.

Rocky Flats Environmental Technology Site (RFETS)

RFETS covers almost 17 square kilometers (7 square miles) in northern Jefferson County, Colorado. The site is located east of the foothills of the Rocky Mountains, approximately 25 kilometers (16 miles) northwest of Denver, Colorado.

RFETS is located in an Air Quality Control Region that is a nonattainment area for the NAAQS criteria pollutants CO, O_3, and PM_{10}.

There are five ephemeral streams at RFETS that form a west-to-east surface drainage pattern. The primary source of flood potential is from flash flooding in these streams; however, most facilities are located outside the 500-year flood plain. No aquifers in the area are sole source aquifers under the Safe Drinking Water Act regulations. The results of 1992 groundwater quality monitoring indicate that the groundwater in the area contains elevated levels of several VOCs, several radionuclides, and other contaminants.

There are 40 federal- and state-listed threatened, endangered, candidate, and other special status species that are known to occur or may occur at RFETS. RFETS has no properties designated as National Historic Landmarks or listed on the NRHP. According to the Colorado Historic Society, portions of the site have been the subject of at least three cultural resource investigations. The historic cultural resources in the area are archaeological sites or standing structures associated with homesteads and ranching.

Five counties comprise the economic ROI; 92.5 percent of the site's 3,500 employees reside in these five counties. In 1990, the ROI population was 1,790,600. The population was predominately White (86.2 percent) with 7.2 percent of the total population living below the poverty level.

The radiation dose from normal operations in 1994 would have resulted in 1×10^{-4} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 2,100,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 1×10^{-7} percent chance of an LCF. The corresponding dose is far below the NESHAP limit.

Savannah River Site (SRS)

SRS is located approximately 20 kilometers (12 miles) south of Aiken, South Carolina, bordering the State of Georgia at the Savannah River. Land use at SRS, which comprises 80,200 hectares (198,000 acres), is generally categorized as forest, water, or developed facility locations. A total of 77,400 hectares (191,000 acres) of SRS are undeveloped, of which 72 percent are forested.

SRS is located near the center of the Augusta-Aiken Interstate Air Quality Control Region. The areas within SRS and its surrounding counties are classified by the EPA as attainment areas with respect to the NAAQS for criteria pollutants.

The site lies within Seismic Zone 2 and is in an area where earthquakes capable of producing structural damage are not likely to occur. Probabilistic seismic hazard curves were developed for all DOE sites in the 1980s, and the results for SRS were that a peak acceleration of 0.19 gravity

LONG DISPOSAL PERIODS AND SEIS-II RESULTS

The action alternatives examined in SEIS-II have waste disposal periods that are much different from the 35-year disposal period of the Proposed Action. Action Alternative 1, all of the Action Alternative 2 subalternatives, and Action Alternative 3 have 160-, 150-, and 190-year disposal periods, respectively. There are three main reasons for these long disposal periods. First, it was assumed that the aboveground configuration of WIPP (principally, the Waste Handling Building and underground access shafts) remains unchanged for all alternatives so waste handling and waste emplacement rates are the same. Second, the waste volumes to be disposed of under the action alternatives would be much greater than the Proposed Action. Third, the final waste form after treatment would affect the volume and heat generation rate of the waste and its ability to meet the WIPP design criteria for thermal loading in the repository.

The large volume of RH-TRU waste in the SEIS-II inventory and the relatively small WIPP throughput rate for RH-TRU waste (8 RH-72B casks per week) are the main reasons for the longer disposal periods for Action Alternatives 1 and 3. Alternative 3 waste volumes would also be increased because of the shred and grout treatment. The disposal period for each Action Alternative 2 subalternative would be increased mainly because of the time required to excavate additional underground panels for RH-TRU waste emplacement. The thermally-treated waste form would have greater radioactivity per volume and thus would have to be distributed over a wide area to meet WIPP thermal loading design criteria.

Assuming the same aboveground WIPP configuration for all action alternatives means that *annual* descriptive parameters and *annual* impacts from TRU waste disposal would be very similar. For example, the same annual work force would be required, the annual WIPP budget would remain the same, and the same annual waste throughput limitations would exist which, as noted above, are particularly important for RH-TRU waste. *In many cases, differences between alternatives are better reflected in long-term, aggregate impacts.* For example, SEIS-II presents aggregate transportation impacts over the entire transportation period, life-cycle costs, socioeconomic impacts over the entire disposal period, lifetime human health impacts, and long-term performance assessment of impacts over the maximally exposed lifetime within the assessment period (if such impacts occur). For these analysis areas, comparing long-term aggregate impacts across alternatives provides more information than comparing annual impacts and better reflects key differences in waste volume and waste treatment methods among alternatives.

was associated with a probability of 2×10^{-4} per year (5,000-year return period). Since 1985, only three earthquakes, all of Richter magnitude 3.0 or less, have occurred in the immediate area of SRS.

The primary surface water feature is the Savannah River, which borders the site for approximately 32 kilometers (20 miles) to the southwest. There are six major streams that flow through SRS into the Savannah River. There are approximately 190 Carolina bays scattered throughout the site. Carolina bays are naturally occurring land depressions that can hold water. The Savannah River and on-site streams are classified as fresh water suitable for primary and secondary contact recreation, as a source for drinking water supply following conventional treatment, fishing, and industrial and agricultural uses. Groundwater quality ranges from excellent (soft and slightly acidic) to poor (exceeding EPA drinking water standards for several constituents) in the vicinity of some waste sites. SRS is included on the CERCLA National Priorities List.

Sixty-one species have been identified at SRS that are listed as threatened, endangered, or having other special status by the state and federal government. No critical habitat for threatened or endangered species exists on SRS. More than 800 prehistoric sites have been identified, although

fewer than 8 percent have been evaluated for eligibility to the NRHP. Approximately 400 historic sites have been identified within SRS. Ten of these sites are eligible for the NRHP.

The SRS economic ROI is composed of four counties in which 87 percent of all SRS employees reside. SRS employees in those counties comprise 4.6 percent of the total employment in the regional economic area. The total population in the ROI in 1990 was 460,028. Approximately 37 percent were minorities; 14 percent were below the poverty level.

The radiation dose from normal operations in 1994 would result in 8×10^{-3} LCF to the population residing within 80 kilometers (50 miles) of the site. The population within this area was 620,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 8×10^{-6} percent chance of an LCF. The corresponding dose is below the NESHAP limit.

ENVIRONMENTAL CONSEQUENCES

The potential environmental consequences of the Proposed Action, three action alternatives, and two no action alternatives are described below. They also are presented in a table at the end of this Summary.

Land Use and Management

Under the Proposed Action, DOE would occupy the land at WIPP transferred to it by the LWA. The Department also would lease selected land outside the WIPP withdrawal area for such uses as groundwater surveillance pads, signs, and transportation and utility corridors. No substantial impacts would occur to established local land use patterns under the Proposed Action. However, the WIPP site would continue to limit drilling and mining activities, and grazing and public access to the site would be controlled. Pursuant to Public Law 104-201, DOE may acquire two oil and gas leases. As part of the decommissioning of the facility, an earthen berm would be constructed above the repository to delimit the 60-hectare (150-acre) disposal area. There would be no impacts to established local land use patterns beyond the site from decommissioning.

For the action alternatives, the area within the earthen berm would be larger and vary from 295 to 324 hectares (730 to 800 acres); otherwise, land use impacts would be similar to the Proposed Action. For the no action alternatives, impacts on the WIPP site would be minimal because there would be no disposal of waste; thus, decommissioning would be limited to the removal of buildings and the sealing of shafts. The disturbed area would not exceed 20 hectares (50 acres).

Construction and operation of TRU waste treatment and storage facilities are expected to have negligible impacts on land uses at DOE treatment and storage sites and are not expected to conflict with site development plans for the following reasons: land requirements for these facilities would be relatively low (less than 11 hectares); the facilities would be located in developed areas or areas appropriate for development; and the facilities would not be located in sensitive areas (such as known cultural resource areas, sensitive habitats, wetlands, and flood plains). The analysis shows that the TRU waste facilities would require less than 1 percent of the land available for waste operations at any DOE site proposed. This would give DOE considerable flexibility in locating the treatment facilities.

Air Quality

Under the Proposed Action and the action alternatives, WIPP disposal operations would result in small increases in the annual average concentrations of PM_{10}, NO_2, and SO_2. In each case, the increase would be less than 2 percent of the respective annual regulatory limit. Releases of the criteria pollutants O_3 and lead from the operation of WIPP would be negligible. Ten years of decommissioning would result in some small increases in annual concentrations of some pollutants but would result in no long-term impacts.

Emissions from WIPP disposal operations could reach higher percentages of the short-term (24-hour) emission limits. These higher percentages, though, were based on conservative modeling assumptions. Emissions of NO_2 for the Proposed Action and for each of the action alternatives could be as high as 65 percent of the 24-hour limit if underground and surface diesel equipment and both backup diesel generators were operating concurrently. The PM_{10} emissions could be as high as 57 percent of the 24-hour limit, due mainly to very conservative assumptions of salt pile fugitive dust emissions.

Except at RFETS, LLNL, and ANL-E, which are in nonattainment areas for some pollutants, most levels of criteria pollutants would be less than 10 percent of applicable regulatory criteria pollutant standards under each alternative. However, during treatment under Action Alternative 2A, radionuclide releases could potentially reach 134 percent of the regulatory standards at RFETS and 48 percent of the standard at SRS. Under Action Alternative 2B, treatment-related releases could reach 48 percent of the regulatory standard at SRS and 10 percent of the standard at INEL. Under Action Alternative 2C, treatment-related releases could reach 319 percent of the regulatory standards at WIPP.

Releases above the regulatory standard would require mitigation measures, such as additional HEPA (High Efficiency Particulate Air) filtration, to ensure releases remained below the allowable limit. Treatment under the other action alternatives or the proposed action would not result in releases of radionuclides or other hazardous or toxic air pollutants in excess of regulatory standards.

Biological Resources

DOE is in the process of conducting surveys at the WIPP site for federally or state listed threatened or endangered species and habitats. DOE will contact the U.S. Fish and Wildlife Service and state agencies concerning the results of these surveys, and when required, DOE will enter into formal consultation under the Endangered Species Act. Based on prior surveys and consultation, disposal operations at WIPP under the Proposed Action are not expected to impact endangered, threatened, or candidate plant and animal species listed by the federal government or endangered, threatened, or rare and sensitive species listed by New Mexico. No critical habitat for endangered or threatened species is known to occur on the WIPP site. WIPP site activities are not expected to affect long-term ecosystem balance or biodiversity, although negligible impacts to the overall plant and animal communities near the WIPP site would occur from WIPP operations. Decommissioning and closure of the WIPP site, which would include reclamation of the salt pile area, would affect a total of 60 hectares (150 acres). These activities would result in the short-term loss of much of the plant community and avian and small mammal habitat within and near the area. DOE would return decommissioned WIPP land to a stable ecological condition and maintain or enhance the condition of wildlife habitat within the WIPP Land Withdrawal Area.

Biological resource impacts for the action alternatives would be similar to those for the Proposed Action, except for an increase in the land that would be disturbed by construction of a berm around the perimeter of, and permanent markers over, the disposal area. The area disturbed by decommissioning under the action alternatives would range from 300 to 330 hectares (730 to 800 acres), an increase of 240 to 260 hectares (590 to 640 acres) over the Proposed Action. Under the no action alternatives, the impacts would be less than those under the Proposed Action because the area disturbed at WIPP would be limited to 20 hectares (50 acres).

Construction and operation of treatment facilities for TRU waste should not affect regional populations of nonsensitive plant and animal species because no more than 11 hectares (28 acres) would be disturbed at any site and because the habitats for these species are well established regionally near the proposed treatment sites. Threatened and endangered species appear at most of the DOE sites considered for waste management and treatment facilities. Such species, therefore, could potentially be impacted. Because relatively little land would be required for the waste management and treatment facilities, DOE should be able to locate the new facilities to avoid impacts to such species and sensitive habitat areas. When specific facility locations are proposed, DOE will contact the U.S. Fish and Wildlife Service and state agencies and enter into formal consultation under the Endangered Species Act, where required.

Cultural Resources

Under the Proposed Action, no impacts to cultural resources would occur as part of the WIPP waste handling or emplacement operations. However, those activities that disturb the land in conjunction with closure and decommissioning may have potentially adverse impacts on two archaeological sites that are located within the 60-hectare (150-acre) surface closure area. Both of these sites are eligible for inclusion on the NRHP. One of these sites may require further testing, avoidance, and mitigation.

Under the action alternatives, shipping and disposal operations at WIPP would not impact the cultural resources of the area. However, decommissioning activities could disturb 11 prehistoric archaeological sites that are potentially eligible for inclusion in the NRHP. These prehistoric archaeological sites are located in a 10-square-kilometer (4-square-mile) area that is centrally located within the WIPP site. Under the no action alternatives, no impacts to known cultural resource properties at WIPP would occur.

Construction and operation of TRU waste management and treatment facilities could adversely affect cultural resources, but because the acreage requirements of these facilities remain relatively low at any one site, the adverse affects can probably be avoided for all alternatives. Site-level cultural resource surveys would be conducted, and protection measures established, where necessary, when specific facility construction locations are proposed.

Noise

Truck transport of waste through Carlsbad under the Proposed Action would result in a negligible increase in background noise levels from normal automobile and truck traffic. Transportation noise impacts were based on a maximum of eight trucks per day, which would correspond to the WIPP throughput rate of 50 TRUPACT-IIs and eight RH-72B casks per week. Most of the waste would enter Carlsbad from the north on Highway 285. Trucks would travel through Carlsbad at random times throughout the day.

Under the action alternatives, noise impacts from trucks would be similar to those of the Proposed Action. If the waste were transported by rail and truck (with rail service used as much as is practical), railroad noise impacts in Carlsbad would increase slightly. The impacts would correspond to the time needed for an additional 13 to 16 fully loaded railroad cars per week to pass through the area. All waste destined for WIPP would travel through Carlsbad to Loving where it would be diverted to WIPP via a dedicated rail spur. For No Action Alternatives 1A and 1B, noise impacts would be negligible from truck or rail transportation during transportation to treatment facilities. For No Action Alternative 2, there would be no transportation and thus no impacts.

Because treatment facilities would probably be placed at industrial-type sites along high traffic volume corridors, construction and operation of those facilities should not substantially increase ambient noise levels. There is a potential for sensitive receptors to be impacted. Impacts to sensitive species or habitats would be mitigated when planning the treatment facilities.

Water Resources and Infrastructure

Annual incremental increases in water, wastewater, or power usage would be negligible and within existing capacity under the Proposed Action and all action alternatives. The WIPP facility has been designed to handle emplacement of the waste volumes proposed and its current or planned infrastructure capacity would not be exceeded. Current roadways and planned traffic volumes due to disposal operations also would be compatible. Under the no action alternatives, use of infrastructure resources would gradually decrease until WIPP were closed. No resources would be used following closure.

Impacts from treatment of the waste were assessed for water, power, wastewater, and on-site transportation needs. Treatment operations under the Proposed Action and Action Alternative 1 would result in a 5.9 percent increase in wastewater at Hanford and minor on-site transportation impacts at Hanford, INEL, and LANL. Action Alternative 2A would result in a 7 percent increase in power usage at INEL, a 7.8 percent increase in wastewater usage at Hanford, and minor on-site transportation impacts at Hanford, INEL, and LANL. Action Alternative 2B would result in a 7 percent increase in power usage at INEL, a 7.8 percent increase in wastewater at Hanford and minor on-site transportation impacts at Hanford and INEL. Action Alternative 2C would result in a 7 percent increase in power usage at INEL and a 50 percent increase in power usage at WIPP. It also would result in 80 percent more wastewater at WIPP, a 162 percent increase in use of on-site transportation resources at WIPP, and minor on-site transportation impacts at Hanford. At WIPP under Action Alternative 2C, increases in the volume of wastewater and road usage would be expected to require new or modified facilities. Action Alternative 3 would result in a 6.4 percent increase in power usage at INEL, a 7 percent increase in wastewater at Hanford, and minor on-site transportation impacts at Hanford, INEL, and LANL. No Action Alternative 1A would result in a 7 percent increase in power usage at INEL, a 7.8 percent increase in wastewater at Hanford, and minor on-site transportation impacts at Hanford, INEL, and LANL. No Action Alternative 1B would result in a 7 percent increase in power usage at INEL, a 7.8 percent increase in wastewater at Hanford, and minor on-site transportation impacts to Hanford and INEL. There would be only minor infrastructure treatment impacts from No Action Alternative 2 because only newly generated waste would be treated.

Socioeconomics

Life-cycle costs for the Proposed Action and the alternatives are presented in Table S-5. The total life-cycle cost of the Proposed Action would be $19.1 billion in 1994 dollars, which includes costs

Table S-5
Life-Cycle Costs (in billions of 1994 dollars)

Life-Cycle Cost Information	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Total Waste Treatment Facility Cost	11.8 (6.6)	21.4 (11.9)	27.7 (15.4)	30.0 (16.7)	28.7 (15.9)	24.4 (13.8)	27.3 (15.1)	27.7 (17.1)	1.9 (1.1)
Total Waste Transport Cost by Truck	1.6 (0.9)	4.9 (0.8)	2.2 (0.4)	2.5 (0.4)	4.9 (0.8)	6.8 (0.9)	0.07 (0.04)	0.24 (0.1)	---
Total Waste Transport Cost by Regular Rail	---	1.6 (0.3)	0.7 (0.1)	0.9 (0.1)	1.2 (0.2)	2.2 (0.3)	0.03 (0.02)	0.16 (0.9)	---
Total Waste Transport Cost by Dedicated Rail	---	11.3 (1.8)	5.1 (0.9)	5.6 (1.0)	9.8 (1.7)	15.7 (2.1)	0.25 (0.1)	1.2 (0.7)	---
Total WIPP Budget	5.3 (2.5)	24.6 (3.7)	23.3 (3.7)	23.3 (3.7)	23.3 (3.7)	28.5 (3.6)	0.85 (0.8)	0.85 (0.8)	0.85 (0.8)
Total Life-Cycle Cost (Truck Transportation)	19.1 (10.1)	50.5 (16.3)	53.2 (19.4)	56.3 (20.8)	56.9 (20.4)	59.7 (18.3)	28.6 (16.0)	31.6 (18.0)	2.7[a]
Total Life-Cycle Cost (Regular Train)	--	47.5 (15.8)	51.6 (19.2)	54.7 (20.6)	53.2 (19.8)	55.0 (17.7)	28.6 (15.9)	31.5 (18.0)	---
Total Life-Cycle Cost (Dedicated Train)	--	57.3 (17.3)	56.0 (19.9)	59.4 (21.4)	61.8 (21.3)	68.5 (19.5)	28.8 (16.1)	32.6 (18.5)	---

Note: The methods and assumptions used to estimate the various life-cycle cost components are described in Appendix D. Actual totals may differ due to rounding and to miscellaneous costs, such as facility decontamination and decommissioning. Discounted costs are presented in parentheses.

[a] Life-cycle cost does not include transportation.

for waste management facilities at 10 treatment sites, waste transport, and WIPP operations. It also includes the storage costs for RH-TRU waste in the Basic Inventory that is in excess of the 7,080 cubic meter (250,000 cubic feet) limit.

For the Proposed Action, the total life-cycle waste treatment cost ($11.8 billion in 1994 dollars) would include construction, operation and maintenance, and decontamination and decommissioning at the 10 treatment sites. The waste management facilities would process, treat, and package waste inventories to meet WAC treatment standards over 35 years. The total cost of waste transportation ($1.6 billion in 1994 dollars) would include consolidation of the waste volumes at the 10 treatment sites and shipment of the treated waste to WIPP over a 35-year period for emplacement. The total budget at WIPP over the life of the project would be $5.3 billion. The cost of storing the excess RH-TRU waste in the Basic Inventory would be $312 million.

Life-cycle costs for the action alternatives and No Action Alternative 1 include costs for managing TRU waste in the Total Inventory, including the Additional Inventory waste, where management costs are not included in the estimated costs for the Proposed Action or No Action Alternative 1. Also, costs for the action alternatives are based on the longer operations times that are outlined in Table S-4.

When truck transportation is proposed, total life-cycle costs would range from $28.6 billion for No Action Alternative 1A to $59.7 billion in 1994 dollars for Action Alternative 3. Of the three transportation modes, regular rail was found to be the least costly and dedicated rail the most costly.

Economic impacts in the WIPP ROI under the Proposed Action and alternatives are presented in Table S-6. Overall, the Proposed Action would have a stabilizing influence on the regional economy near WIPP. Similarly, WIPP would remain a stable federal employer under the other action alternatives, providing direct employment for 1,095 project personnel. The continued operation of WIPP would provide annual direct and indirect production of $505 million of goods and services in 1994 dollars, $120 million of annual labor income in 1994 dollars, and support the employment of 3,371 individuals (including the 1,095 project personnel). These economic impacts are based on an assumed average annual project budget of $180 million per year in 1994 dollars over a 35-year waste emplacement period extending from 1998 through 2033. In contrast, the economic impacts under the no action alternatives include job losses in Eddy and Lea counties and accompanying declines in the production of goods and services and labor income.

Table S-6
Economic Impacts in the WIPP ROI[a]

SEIS-II Alternative	Duration of Waste Disposal Operations	Annual Output of Goods and Services in millions of 1994 Dollars)	Direct and Indirect Employment	Annual Labor Income (in millions of 1994 Dollars)
Proposed Action	35 years	500 (275)	3,400	120 (65)
Action Alternative 1	160 years	500 (80)	3,400	120 (20)
Action Alternatives 2A and 2B	150 years	500 (80)	3,400	120 (20)
Action Alternative 2C	150 years	1,000 (150)	6,600	230 (40)
Action Alternative 3	190 years	500 (65)	3,400	120 (15)
No Action Alternative 1	NA	-50 (-40)	-340	-12 (-10)
No Action Alternative 2	NA	-50 (-40)	-340	-12 (-10)

[a] Numbers have been rounded. Numbers presented in parentheses have been discounted based on a 4.1 percent discount rate.

TRU waste treatment activities would result in creation of additional direct, indirect, and induced jobs. Under the Proposed Action approximately 5,700 jobs would be created in the ROIs of the ten treatment sites (ANL-E, Hanford, INEL, LANL, LLNL, Mound, NTS, ORNL, RFETS, SRS). Under the action alternatives, the approximate number of jobs created ranged from 10,600 for Action Alternative 2C to 15,700 under Action Alternative 2A. Approximately 15,700 jobs would be created to treat waste under No Action Alternative 1A and 15,500 would be created to treat waste under No Action Alternative 1B. Approximately 800 jobs would be created to treat and manage waste under No Action Alternative 2.

Transportation

The following are among the analyses conducted to estimate impacts from transporting TRU waste:

- The overall number of traffic accidents and the number of resulting fatalities and injuries were estimated. These impacts are dependent upon the number of additional trucks that transportation of TRU waste would place on the nation's highways and not on the radioactive or hazardous materials being transported. These impacts, therefore, are "nonradiological impacts."

- Accident-free radiological impacts were estimated. These impacts are associated with the external radiation present around a TRUPACT-II or RH-72B as it is being shipped. The general public and transportation workers would be exposed to very low levels of radiation both during transportation and while a shipment is stopped. These impacts are "accident-free radiological impacts."

- The impacts from specific accident scenarios in which a TRU waste package is breached and releases radioactive or hazardous materials were estimated. These impacts are "radiological impacts from transportation accidents."

The following subsections discuss the results of these analyses.

Nonradiological Impacts

Under the Proposed Action, during the 35 years of transportation, 76 accidents, 48 injuries, and six fatalities were estimated for transportation of TRU waste by truck. The greatest potential impacts would occur under Action Alternative 3, with 331 accidents, 208 injuries, and 25 fatalities during 190 years of transportation by truck. The impacts from truck transportation of TRU waste under Action Alternative 1 would be 237 accidents, 148 injuries, and 19 fatalities during the 160 years of transportation. The impacts for the three subalternatives of Action Alternative 2 indicate that the number of accidents during the 150 years of transportation would range from 107 to 140, the number of injuries would range from 66 to 87, and the number of fatalities would range from 9 to 12. Under No Action Alternative 1A, the impacts from truck transportation would be three accidents, no injuries, and no fatalities during the 35 years of transportation. The impacts from truck transportation of TRU waste under No Action Alternative 1B would be 14 accidents, 13 injuries, and 1 fatality during 35 years of transportation. There would be no transportation proposed under No Action Alternative 2.

If regular rail service were used as much as practical, with trucks transporting the remainder of the waste for the action alternatives or No Action Alternative 1, the number of fatalities overall would be approximately half those estimated for truck transportation alone. This is because the number

of fatalities per rail-car mile and per truck are about the same and because twice as many TRUPACT-IIs or RH-72B casks can be shipped on each rail car; the number of shipments (and fatalities), therefore, is reduced by half.

If dedicated rail service were used for the action alternatives or No Action Alternative 1 with rail cars shipping TRU waste exclusively, approximately 12 times the number of truck fatalities for each alternative would be expected as a result. This is largely from the increase in the number of trains when dedicated rail service is used.

Accident-Free Radiological Impacts

Two types of accident-free radiological impacts were independently estimated. The first type was the nonoccupational impact: the impact to the general public living along the highways or traveling on the highways at the same time as the TRU waste shipments. The second was the occupational impact: the impact to inspectors and others whose jobs would expose them to the radiation from TRUPACT-IIs and RH-72B casks.

Under the Proposed Action, nonoccupational impacts could result in 3 LCFs. Among the alternatives, Action Alternative 3 would have the greatest nonoccupational, accident-free radiological impact from truck transportation (14 latent cancer fatalities or LCFs). No Action Alternative 1A would have the least nonoccupational radiological impact (less than 1 LCF). (No transportation is proposed for No Action Alternative 2.) Action Alternatives 2A and 2B would have nonoccupational impacts estimated at 5 LCFs, Action Alternative 2C would have 6 LCFs, and Action Alternative 1 would have 11 LCFs.

Nonoccupational, accident-free exposure impacts from rail transportation are generally ten times lower than those impacts from truck transportation, due to additional shielding during stops. Action Alternative 3 would have the maximum potential impact for accident-free rail transport (1.9 LCFs).

Under the Proposed Action, accident-free occupational impacts from truck transportation would result in 0.3 LCF. Action Alternative 3 would have the greatest occupational impacts, resulting in 1 LCF from accident-free transportation. Accident-free transportation under Action Alternatives 2A and 2B would result in 0.4 LCF each, and 0.6 LCF would result from Action Alternative 2C. Under Action Alternative 1 and No Action Alternatives 1A and 1B, the occupational impacts would result in 0.7, 5.2×10^{-3}, and 0.07 LCF, respectively.

Occupational accident-free doses from rail transportation could be up to 100 times lower than from truck transportation, due to the lower number of shipments (half as many) and the increased distance between the shipping containers or casks and the crews. Also, no impacts would be expected from the release of hazardous chemicals in TRU mixed waste during accident-free transportation, because the containers used to transport the waste are not vented and, therefore, no releases would occur.

Radiological Impacts From Transportation Accidents

Two types of analyses were conducted to determine the radiological impacts associated with transportation accidents. The first estimated the aggregate radiological impacts during transportation from each of the 10 major treatment sites to WIPP. For this analysis, a conservative

ESTIMATING RADIOLOGICAL IMPACTS

Estimation of potential human health impacts involves a series of calculations that indicate the potential health consequence of a particular action or accident, and the probability that the action or accident would occur. Impacts can be calculated both for individuals and for a population. The probability of occurrence for routine actions is 1.0, meaning the action (e.g., chronic release from a permitted exhaust point) will occur at regular intervals, typically daily, over a year of operations. The probability of occurrence for accidents, therefore, is between zero and 1.0, indicating that the nonroutine event might be expected to occur at some random point in time over the entire operations period.

The health effect of concern from low levels of radiation exposure is a radiation-induced cancer fatality. To quantify the radiological impact, the radiation dose must be calculated. The dose is a function of the exposure pathway (external, inhalation, or ingestion) and the type and quantity of radionuclides involved. After the dose is estimated, the health impact is calculated from current internationally-recognized risk factors. For this document, potential radiological impacts are based on a scenario that includes prudently conservative release, exposure, and risk factor estimates. The impact estimates bound any that would be expected because of the use of conservative assumptions.

The unit of radiation dose for an individual is the rem. A millirem (mrem) is 1/1,000 of a rem. The unit of dose for a population is person-rem and is determined by summing the individual doses of an exposed population. Dividing the person-rem estimate by the number of people in the population would indicate the average dose to a single individual. The impacts from a small dose to a large number of people can be approximated by the use of population (i.e., collective) dose estimates.

To estimate the human health impact from radiation dose, a dose-to-risk factor that indicates the potential for a latent cancer fatality, or LCF, is used. An LCF is a fatality resulting from a cancer that was originally induced by radiation, but which may occur years after the exposure. The dose-to-risk factor for low (less than 20 rem) annual doses is 0.0005 LCF per person-rem for the general public, which includes the very young and the very old, and 0.0004 for the worker population. For example, a population dose of 2,000 person-rem is estimated to result in one additional cancer fatality (0.0005 x 2,000 = 1) in the general public. The dose-to-risk factor for an individual is doubled if the individual dose is greater than 20 rem/year (20,000 mrem per year).

The average individual in the United States receives a dose of 0.3 rem (300 mrem) each year from background radiation. Background radiation sources include radon that has concentrated in homes from foundation soil sources, uranium found in rocks used as building materials, and cosmic radiation from the earth's atmosphere. The average lifetime chance or probability of cancer to a member of the public from a 70-year exposure due to background radiation is 0.01 (70 x 0.3 x 0.0005). That is, the best current radiation risk estimates are that one in 100 people will die from cancer due to background radiation.

radionuclide inventory was used that assumed every TRU waste package would be filled with waste containing the highest level of radionuclides and hazardous material allowed by the planning-basis WAC. The probabilities of occurrence for each of eight severity categories, the distance from each site, and the number of shipments were considered for this first analysis. The total accident impact from each of the 10 sites was obtained by summing the impacts calculated for each severity category.

For each alternative except Action Alternative 3, the total LCFs were estimated to be less than 1. For Action Alternative 3, the estimate was 1.2 LCFs.

The second type of analysis assessed bounding accident scenarios. Two scenarios involved the breach of a TRUPACT-II and two involved the breach of an RH-72B. The accidents were assumed to occur under conditions that would maximize, within reasonable bounds, the impacts to exposed population groups. Results for this second analysis are summarized below:

- *Breach of a TRUPACT-II with a maximum radionuclide inventory*: The inventory considered for this analysis was a shipment of three TRUPACT-IIs, each with the maximum number of drums, and each drum containing the maximum level of radionuclides permitted under the planning-basis WAC. The accident scenario considered the breach of one of the three TRUPACT-IIs in an urban area under weather conditions that would maximize the radiation dose to the population. The analyses indicated that for the Proposed Action, Action Alternative 1, Action Alternative 2C, Action Alternative 3, and No Action Alternatives 1A and 1B, the radiation dose to the population would result in 16 LCFs, and the dose to the MEI would result in a 6 percent chance of an LCF. For Action Alternatives 2A and 2B, the dose to the population would result in less than 1 LCF and that to the MEI would result in a 0.02 percent chance of an LCF. The reduced impacts are due to thermal treatment before shipment to WIPP. Impacts to a transportation crew member would not be expected to exceed those to the MEI.

- *Breach of an RH-72B with a maximum radionuclide inventory*: The inventory considered for this analysis was a shipment of one RH-72B cask containing the maximum level of radionuclides permitted under the planning-basis WAC. The accident scenario considered the breach of the RH-72B cask in an urban area under weather conditions that would maximize the radiation dose to the population. The analyses indicated that for the Proposed Action, Action Alternatives 1 and 3, and No Action Alternatives 1A and 1B, the radiation dose to the population would result in 16 LCFs, and the dose to the MEI would result in a 6 percent chance of an LCF. For Action Alternatives 2A, 2B, and 2C, the dose would result in less than 1 LCF and that to the MEI would result in a 0.02 percent chance of an LCF. The reduced impacts are due to thermal treatment before shipment to WIPP. Impacts to a transportation crew member would not be expected to exceed the MEI.

- *Breach of a TRUPACT-II with average concentrations of radionuclides*: The inventory considered for this analysis was a shipment of three TRUPACT-IIs containing the average concentration of radionuclides found at SRS, which had the highest average concentration. The accident scenario was otherwise identical to that above. The analyses indicated that for the Proposed Action, Action Alternative 1, Action Alternative 2C, Action Alternative 3, and No Action Alternatives 1A and 1B, the radiation dose to the population would result in 3 LCFs, and the dose to the MEI would result in a 4 percent chance of an LCF. For Action Alternatives 2A and 2B, the dose to the population would result in less than 1 LCF and that to the MEI would result in a 0.02 percent chance of an LCF. The reduced impacts are again due to thermal treatment before shipment to WIPP. Impacts to a transportation crew member would not be expected to exceed those to the MEI.

- *Breach of an RH-72B with average concentrations of radionuclides*: The inventory considered for this analysis was a shipment of an RH-72B cask containing the average concentration of radionuclides found at Hanford, which had the highest average concentration. The accident was otherwise identical to that above. The analyses indicated that for the Proposed Action, Action Alternative 1, Action Alternative 2C, Action Alternative 3, and No Action Alternatives 1A and 1B, the dose to the population would result in 0.04 LCF, and the dose to the MEI would result in a 0.07 percent chance of an

LCF. For Action Alternatives 2A, 2B and 2C, the dose to the population would result in less than 1 LCF and that to the MEI would result in a 2.0×10^{-4} percent chance of a LCF. The reduced impacts are again due to thermal treatment of the waste before shipment to WIPP. Impacts to a transportation crew member would not be expected to exceed those to the MEI.

The severe rail transportation accident analyses assumed the breach of two RH-72B casks or two TRUPACT-IIs; thus, the impacts for a rail accident would double those calculated for a truck accident.

In an effort to reduce the impacts estimated in the transportation analysis, the carrier selected by DOE would provide tractors and drivers who would not work on other contracts. The drivers would be technically qualified and experienced and would be required to complete training in 28 categories, including hazardous and radioactive material transportation. Drivers would carry instructions regarding protocol in the event of an accident and would be trained in package recovery operations. The DOE Carlsbad Area Office has completed and made available an emergency-response plan involving TRU material transport.

Human Health (During Accident-Free Operations)

Potential human health impacts estimated in SEIS-II analyses include the impacts from waste treatment (for all alternatives), waste storage (for all alternatives), and waste disposal at WIPP (for the Proposed Action and the action alternatives). The impacts presented include lifetime exposure to radiation and hazardous chemicals for members of the public, workers not directly involved in handling containers of TRU waste (called noninvolved workers), and workers who would directly handle containers of TRU waste (called involved workers). The findings included the following:

UNDERSTANDING SCIENTIFIC AND EXPONENTIAL NOTATION

Scientific notation is used in this document to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers (or exponents) of 10. A number written in scientific notation is expressed as the product of a number between 1 and 10 and a positive or negative power of 10. Examples include the following:

Positive Powers of 10	**Negative Powers of 10**
$10^1 = 10 \times 1 = 10$	$10^{-1} = 1/10 = 0.1$
$10^2 = 10 \times 10 = 100$	$10^{-2} = 1/100 = 0.01$
and so on, therefore,	and so on, therefore,
$10^6 = 1{,}000{,}000$ (or 1 million)	$10^{-6} = 0.000001$ (or 1 in 1 million)

A power of 10 is also commonly expressed as "E", where "E" means "x 10". For example, 3×10^5 can also be written as 3E+5, and 3×10^{-5} is equivalent to 3E-5. Therefore, 3E+5=300,000 and 3E-5 = 0.00003. This is called exponential notation.

The data tables in this section use exponential notation for numbers that are either very large or very small. The text uses scientific notation to convey these numbers.

Probability is expressed as a number between 0 and 1 (0 to 100 percent likelihood of the occurrence of an event). The notation 3E-6 can be read 0.000003, which means that there are three chances in 1,000,000 that the associated result (e.g., fatal cancer) will occur in the period covered by the analysis.

- No incidence of cancer or noncarcinogenic health effects from exposure to the hazardous chemicals in TRU mixed waste would be anticipated to the public or workers under any alternative.

- Thermal treatment of waste under Action Alternatives 2A, 2B, and 2C, and under No Action Alternatives 1A and 1B could result in 1 to 5 radiation-related LCFs, depending on the alternative and the treatment site, to members of the public at the treatment sites due to the thermal treatment. No LCFs from treatment for members of the public would occur under any other alternative, including the Proposed Action. Waste treatment could result in 3 to 5 LCFs in involved worker populations under Action Alternatives 1, 2A, 2B, 2C, 3 and No Action Alternatives 1A and 1B. Waste treatment (to meet planning-basis WAC) could result in 2 LCFs to involved worker populations under the Proposed Action. Under No Action Alternative 2, storage operations could result in 1 LCF to involved worker populations.

- Waste disposal operations at WIPP could result in 1 LCF to involved worker populations under the Proposed Action and Action Alternative 1. The other action alternatives would have no LCFs for the involved workers.

- No radiation-related LCFs would be anticipated among the noninvolved worker population under any alternative.

Proposed Action

For members of the public, treatment of CH-TRU and RH-TRU waste to meet the planning-basis WAC would result in radiological impacts of 2×10^{-4} LCF for the total population within 80 kilometers (50 miles) of all treatment facilities. For the MEI, the radiological impacts would be a 9×10^{-7} percent chance of an LCF. Hazardous chemical impacts would include a cancer incidence of 4×10^{-7} in the population within 80 kilometers (50 miles) of the treatment facilities. The impact to the MEI would be a 8×10^{-10} percent chance of cancer.

Storage of the excess RH-TRU waste inventory at Hanford and ORNL would result in radiological impacts to the public of 2×10^{-5} LCF in the population and a 1×10^{-7} percent chance of an LCF for the MEI (at ORNL only). Hazardous chemical impacts include a cancer incidence of 3×10^{-4} in the total population and a 4×10^{-6} percent chance of an LCF for the MEI (at ORNL)[1].

Disposal operations at WIPP would result in the radiological impacts to the public of 3×10^{-4} LCF in the population and a 3×10^{-5} percent chance of an LCF for the MEI. Hazardous chemical impacts would include a cancer incidence of 2×10^{-5} in the population and a 3×10^{-6} percent chance of cancer for the MEI.

For noninvolved workers (those who would not directly handle TRU waste), the radiological impacts from treatment of CH-TRU and RH-TRU waste would be 2×10^{-5} LCF to the total noninvolved worker population of all treatment facilities. The impacts to the maximally exposed noninvolved worker would be a 7×10^{-7} percent chance of an LCF. Hazardous chemical impacts

[1] Hazardous chemical impacts are relatively high compared to radiological impacts because TRU waste containers are vented through carbon filters which filter out radioactive particulates. The gases that vent through the filters are relatively high in hazardous constituents while few gaseous radionuclides are emitted.

would include a cancer incidence of 1×10^{-7} in the total noninvolved worker population of all the treatment facilities and a 5×10^{-9} percent chance of cancer for the maximally exposed noninvolved worker.

Storage of the excess RH-TRU inventory at Hanford and ORNL would result in radiological impacts to the noninvolved worker populations of 4×10^{-5} and a 1×10^{-6} percent chance of an LCF for the MEI (at ORNL). Hazardous chemical impacts would include a cancer incidence of 6×10^{-4} in the total noninvolved worker population and a 4×10^{-6} percent chance of cancer incidence for the maximally exposed noninvolved worker (at Hanford).

Radiological impacts to the noninvolved worker from disposal operations at WIPP could result in 4×10^{-4} LCF in the noninvolved worker population and a 4×10^{-5} percent chance of an LCF for the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1×10^{-4} in the noninvolved population and a 1×10^{-5} percent chance of cancer for the maximally exposed noninvolved worker.

For involved workers (those who would handle TRU waste directly), the radiological impacts from treatment of CH-TRU and RH-TRU waste could be 2 LCFs to the total involved worker population of all treatment facilities. Hazardous chemical impacts would include a cancer incidence of 0.04 in the total involved worker population of all the treatment facilities.

From disposal operations at WIPP, radiological impacts would result in 0.6 LCF in the involved worker population. Hazardous chemical impacts would result in a cancer incidence of 0.01 in the involved worker population.

Impacts to the involved and the noninvolved workers from storage of the excess RH-TRU waste, treatment to meet the planning-basis WAC and disposal at WIPP would be administratively controlled to ALARA (as low as reasonably achievable) levels.

Action Alternative 1

For members of the public, treatment to planning-basis WAC of CH-TRU and RH-TRU waste would result in radiological impacts of 2×10^{-4} LCF for the total population within 80 kilometers (50 miles) of all treatment facilities. For the MEI, the radiological impacts would be a 1×10^{-6} percent chance of an LCF. Hazardous chemical impacts would include a cancer incidence of 4×10^{-7} in the population within 80 kilometers (50 miles) of the treatment facilities and a 8×10^{-10} percent chance of cancer to the MEI. Lag storage at treatment sites would result in radiological impacts to the public of 1×10^{-2} LCF in the population and a 2×10^{-4} percent chance of an LCF for the MEI (ORNL). Hazardous chemical impacts would include a cancer incidence of 3×10^{-3} in the population and a 1×10^{-5} percent chance of an LCF for the MEI (LANL).

Disposal operations at WIPP would result in radiological impacts to the public of 3×10^{-4} LCF in the population and a 5×10^{-5} percent chance of an LCF for the MEI. Hazardous chemical impacts would include a cancer incidence of 2×10^{-5} in the population and a 2×10^{-6} percent chance of cancer for the MEI.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from the treatment of CH-TRU and RH-TRU waste would be 2×10^{-5} LCF in the total noninvolved worker population of all treatment facilities and an 8×10^{-7} percent chance of an LCF to the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer

incidence of 1×10^{-7} in the total noninvolved worker population of all treatment facilities and a 5×10^{-9} percent chance of cancer for the maximally exposed noninvolved worker. Lag storage at the treatment sites would result in radiological impacts at 4×10^{-2} LCF in the population and an 8×10^{-4} percent chance of an LCF for the maximally exposed noninvolved worker (ORNL). Hazardous chemical impacts would include cancer incidence of 5×10^{-3} in the population and a 5×10^{-5} percent chance of an LCF for the maximally exposed noninvolved worker (INEL).

Disposal operations at WIPP would result in radiological impacts at 4×10^{-4} LCF in the noninvolved worker population and a 4×10^{-5} percent chance of an LCF for the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1×10^{-4} in the noninvolved population and a 9×10^{-6} percent chance of cancer for the maximally exposed noninvolved worker.

For involved workers (those handling TRU waste directly), the radiological impacts from treatment of CH-TRU and RH-TRU waste would be 3 LCFs in the total involved worker population of all the treatment facilities. Hazardous chemical impacts would include a cancer incidence of 6×10^{-5} in the total involved worker population of all the treatment facilities.

Lag storage at treatment sites would result in radiological impacts of 1 LCF in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 0.04 in the involved worker population.

Disposal operations at WIPP would result in radiological impacts of 0.8 LCF in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 0.03 in the involved worker population.

Action Alternative 2

For members of the public, treatment of CH-TRU and RH-TRU waste under Action Alternatives 2A, 2B, and 2C would result in radiological impacts of 5, 3, and 1 LCFs, respectively, in the total population within 80 kilometers (50 miles) of all treatment facilities and a 9×10^{-3}, 2×10^{-3}, and 0.03 percent chance of an LCF, respectively, to the MEI. Hazardous chemical impacts would include a cancer incidence of 4×10^{-7}, 3×10^{-5}, and 5×10^{-7} , respectively, in the population within 80 kilometers (50 miles) of the treatment facilities and a 7×10^{-10}, 6×10^{-10}, and 9×10^{-10} percent chance of cancer to the MEI.

Lag storage at treatment sites under the Action Alternatives 2A, 2B, and 2C would result in radiological impacts to the public of 1×10^{-3}, 6×10^{-4}, and 1×10^{-4} LCF, respectively, in the population, and 2×10^{-5} (at LANL), 1×10^{-6} (at SRS), and 1×10^{-5} (at WIPP) percent chance of an LCF, respectively, for the MEI. There would be no hazardous chemical impacts because thermal treatment would remove most hazardous constituents.

Disposal operations at WIPP under each Alternative 2 subalternative would result in radiological impacts to the public of 5×10^{-5} LCF in the population and a 1×10^{-5} percent chance of an LCF for the MEI. For each subalternative, there would be no hazardous chemical impacts.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from treatment of TRU waste under Action Alternatives 2A, 2B, and 2C would be 0.5, 0.3, and 0.09 LCF, respectively, in the total noninvolved worker population of all the treatment facilities and a 3×10^{-2} (at LANL), 2×10^{-2} (at SRS), and 3×10^{-2} (at WIPP) percent chance of an LCF to

the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1×10^{-7} in the total noninvolved worker population of all the treatment facilities and a 4×10^{-9} percent chance of cancer for the maximally exposed noninvolved worker.

Lag storage at the treatment sites would result in radiological impacts of 2×10^{-2} , 2×10^{-2}, and 4×10^{-4} LCF in the population and a 1×10^{-4} (SRS), 1×10^{-4} (SRS), and 1×10^{-5} (WIPP) percent chance of an LCF for the maximally exposed noninvolved worker. There would be no hazardous chemical impacts because thermal treatment would remove most hazardous constituents.

Disposal operations at WIPP would result in radiological impacts of 2×10^{-4} LCF in the noninvolved worker population and a 2×10^{-5} percent chance of an LCF for the maximally exposed noninvolved worker for all subalternatives. There would be no hazardous chemical impacts because thermal treatment would remove most hazardous constituents.

For involved workers (those handling TRU waste directly), the radiological impacts from treatment of CH-TRU and RH-TRU waste would be 5, 5, and 3 LCFs in the total involved worker population at all the treatment facilities. Hazardous chemical impacts would include a cancer incidence of 2×10^{-4}, 2×10^{-4}, 4×10^{-4} in the total involved worker population of all the treatment facilities.

Lag storage at treatment sites would result in radiological impacts at 0.4 LCF in the involved worker population. There would be no hazardous chemical impacts.

Disposal operations at WIPP would result in radiological impacts at 0.2 LCF in the involved worker population. There would be no hazardous chemical impacts.

Action Alternative 3

For members of the public, treatment of CH-TRU and RH-TRU waste would result in radiological impacts of 4×10^{-4} LCF in the total population within 80 kilometers (50 miles) of all the treatment facilities and a 2×10^{-6} percent chance of an LCF to the MEI. Hazardous chemical impacts would include a cancer incidence of 8×10^{-7} in the population within 80 kilometers (50 miles) of the treatment facilities and a 1×10^{-9} percent chance of cancer to the MEI.

Lag storage at treatment sites would result in radiological impacts of 2×10^{-3} LCF in the population and a 3×10^{-5} percent chance of an LCF for the MEI (at LANL). Hazardous chemical impacts would include a cancer incidence of 2×10^{-3} in the population and a 3×10^{-5} percent chance of an LCF for the MEI (at Hanford).

Disposal operations at WIPP would result in radiological impacts of 2×10^{-4} LCF in the population and a 3×10^{-5} percent chance of an LCF for the MEI. Hazardous chemical impacts would include a cancer incidence of 1×10^{-5} in the population and a 1×10^{-6} percent chance of cancer for the MEI.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from the treatment of TRU waste would be 4×10^{-5} LCF in the total noninvolved worker population of all treatment facilities and a 2×10^{-6} (LANL) percent chance of an LCF to the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 3×10^{-7} in the total noninvolved worker population at all the treatment facilities and a 9×10^{-9} (ORNL) percent chance of cancer for the maximally exposed noninvolved worker.

Lag storage at treatment sites would result in radiological impacts at 4 x 10^{-2} LCF in the population and a 2 x 10^{-4} percent chance of an LCF for the maximally exposed noninvolved worker (SRS). Hazardous chemical impacts would include a cancer incidence of 5 x 10^{-3} in the population and a 4 x 10^{-5} percent chance of an LCF for the maximally exposed noninvolved worker (Hanford).

Disposal operations at WIPP would result in radiological impacts of 3 x 10^{-4} LCF in the noninvolved worker population and a 3 x 10^{-5} percent chance of an LCF for the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 5 x 10^{-5} in the noninvolved worker population and a 5 x 10^{-6} percent chance of cancer for the maximally exposed noninvolved worker.

For involved workers (those handling TRU waste directly), the radiological impacts from treatment of CH-TRU and RH-TRU waste would be 4 LCFs in the total involved worker population at all the treatment facilities. Hazardous chemical impacts would include a cancer incidence of 1 x 10^{-4} in the total involved worker population at all the treatment facilities.

Lag storage at treatment sites would result in radiological impacts at 0.6 LCF in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 0.1 in the involved worker population.

Disposal operations at WIPP would result in radiological impacts at 0.2 LCF in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 7 x 10^{-3} in the involved worker population.

No Action Alternative 1

For members of the public, treatment of TRU waste under No Action Alternatives 1A and 1B would result in radiological impacts of 5 and 3 LCFs, respectively, in the total population within 80 kilometers (50 miles) of all treatment facilities and a 9 x 10^{-3} (at LANL) and 2 x 10^{-3} (SRS) percent chance of an LCF, respectively, to the MEI. Hazardous chemical impacts would include a cancer incidence of 4 x 10^{-7} and 3 x 10^{-7} in the population within 80 kilometers (50 miles) of the treatment facilities and a 6 x 10^{-10} (ORNL) percent chance of cancer to the MEI under both subalternatives.

Storage operations at the treatment sites would result in radiological impacts of 1 x 10^{-3} and 7 x 10^{-4} in the population and a 2 x 10^{-5} (LANL) and 2 x 10^{-7} (ORNL) percent chance of an LCF for the MEI. There would be no hazardous chemical impacts.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from treatment of TRU waste under No Action Alternatives 1A and 1B would be 0.5 and 0.3 LCF in the total noninvolved worker population of all the treatment facilities and a 3 x 10^{-2} (LANL) and 2 x 10^{-2} (SRS) percent chance of an LCF to the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1 x 10^{-7} in the total noninvolved worker population of all the treatment facilities and a 4 x 10^{-9} percent chance of cancer for the maximally exposed noninvolved worker under both subalternatives.

Storage operations at treatment sites would result in radiological impacts of 2 x 10^{-2} LCF in the population and a 1 x 10^{-4} (SRS) percent chance of an LCF for the maximally exposed noninvolved worker. There would be no hazardous chemical impacts.

For involved workers (those handling TRU waste directly), treatment of CH-TRU and RH-TRU waste would result in radiological impacts of 5 LCFs for each subalternative in the total involved worker population of all the treatment facilities. Hazardous chemical impacts would include a cancer incidence of 2×10^{-4} and 3×10^{-4} in the total involved worker population of all the treatment facilities.

Storage operations at consolidation sites would result in radiological impacts of 0.4 LCF in the involved worker population.

No Action Alternative 2

For members of the public, treatment of TRU waste under No Action Alternative 2 would result in radiological impacts of 2×10^{-4} LCF in the total population within 80 kilometers (50 miles) of all treatment facilities and a 9×10^{-7} percent chance of an LCF (at LANL) to the MEI. Hazardous chemical impacts would include a cancer incidence of 4×10^{-7} in the population within 80 kilometers (50 miles) of the treatment facilities and 7×10^{-10} percent chance of cancer (at ORNL) to the MEI.

Storage operations at generator sites would result in radiological impacts of 1×10^{-2} LCF in the population and 2×10^{-4} (ORNL) percent chance of an LCF for the MEI. Hazardous chemical impacts would include a cancer incidence of 2×10^{-3} in the population and 4×10^{-6} (LANL) percent chance of cancer to the MEI.

For noninvolved workers (those not handling TRU waste directly), the radiological impacts from the treatment of TRU waste would be 2×10^{-5} LCF in the total noninvolved worker population of all the treatment facilities and a 7×10^{-7} percent chance of an LCF (at LANL) to the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 1×10^{-7} in the total noninvolved worker population of all the treatment facilities and a 5×10^{-9} percent chance of cancer (ORNL) for the maximally exposed noninvolved worker.

Storage operations at generator sites would result in radiological impacts of 0.04 LCF in the population and a 4×10^{-3} (ORNL) percent chance of an LCF for the maximally exposed noninvolved worker. Hazardous chemical impacts would include a cancer incidence of 2×10^{-3} LCF in the population and 2×10^{-5} (INEL) percent chance of cancer to the maximally exposed noninvolved worker.

For involved workers (those handling TRU waste directly), the radiological impacts from the treatment of TRU waste would be 8×10^{-2} LCF in the total involved worker population at all the treatment facilities. Hazardous chemical impacts would include a cancer incidence of 4×10^{-6} in the total involved worker population at all the treatment facilities.

Storage operations at generator sites would result in radiological impacts of 1 LCF in the involved worker population. Hazardous chemical impacts would include a cancer incidence of 0.04 in the involved worker population.

Facility Accidents

Potential radiological impacts from treatment, storage, and disposal facility accidents were analyzed and are presented in this discussion. Although the initiating events of the accidents vary for the three stages (treatment, storage, and disposal), the general approach was to evaluate: (1) a

high-frequency/low-consequence accident for each of the three stages; (2) a low-frequency/ high-consequence operational accident for each of the three stages; and (3) an accident that would be beyond-design-basis of and involve the collapse of the applicable treatment or storage facility. A potential beyond-design-basis accident could be triggered by a number of initiating events, such as an earthquake, tornado, or plane crash, depending on the site. For the purposes of analysis in SEIS-II, an earthquake is assumed to initiate the beyond-design-basis accident for treatment and storage facilities. While the annual frequency of a design-basis earthquake varies for DOE sites across the country (1×10^{-3} or less), the frequency of a beyond-design-basis earthquake that would result in a loss of confinement and a collapse of the building has been estimated at 1×10^{-5} for purposes of these analyses. The analyses were conducted to estimate the difference in impacts among the types of waste treatment and not to make a decisions regarding specific treatment sites.

The results presented below are those for the high-frequency/low-consequence accident (with estimated annual occurrence frequencies of 0.1 to 0.01), the beyond-design-basis earthquake accident and the hoist failure accident, which provide the range of consequences for the accidents evaluated.

The analyses were conducted in such a manner as to indicate the differences between the types of waste treatment and not to make a decision regarding specific treatment sites. The impacts were calculated for specific sites based on TRU waste inventory, population, and types of treatment.

Treatment Facility Accidents

High-Frequency/Low-Consequence Accident (Waste Spill/Waste Drum Failure)

The maximum radiological impact to the public from a high-frequency/low-consequence accident during the treatment of TRU waste to meet the planning-basis WAC would be at ORNL where 4×10^{-4} LCFs were estimated. The highest thermal treatment impact would be at Hanford where 3×10^{-5} LCFs were estimated. Treatment by shred and grout would have a maximum impact of 1×10^{-4} at ORNL.

Maximum radiological impacts to the MEI would range from a 3×10^{-5} percent chance of an LCF at ORNL for the treatment of TRU waste to the planning-basis WAC, to a 2×10^{-6} percent chance of an LCF at LANL and WIPP for thermally treated waste. The maximum radiological impact to the MEI for shred and grout treatment was estimated as a 1×10^{-5} percent chance of an LCF at ORNL.

For the alternatives that consider treatment of TRU waste to the planning-basis WAC, the maximum radiological impact to the maximally exposed noninvolved worker were estimated as a 5×10^{-5} percent chance of an LCF at Hanford. For alternatives that include thermally treating waste, the maximum impact would be at Hanford for which a 4×10^{-6} percent chance of an LCF was estimated. For the alternative that considers treating TRU waste using a shred and grout process, the maximum impact to the maximally exposed noninvolved worker was estimated as a 1×10^{-5} percent chance of an LCF at Hanford, LANL, and ORNL.

Beyond-Design-Basis Accident (Collapse of Building Due to Earthquake)

The population impact from a beyond-design-basis accident during the treatment of TRU waste to meet planning-basis WAC would be 1 LCF at ORNL (Proposed Action, Action Alternative 1, Action Alternative 2C, and No Action Alternative 2). Treatment by shred and grout (Action

Alternative 3) would have a maximum impact of 10 LCFs at ORNL. Thermal treatment (Action Alternatives 2A and 2B and No Action Alternative 1) would have an impact of 30 LCFs at ORNL.

Impacts to the MEI would range from a 2 percent chance of an LCF at ORNL for the thermal treatment of TRU waste (Action Alternatives 2A and 2B and No Action Alternative 1) to an 0.08 percent chance of an LCF at ORNL (Proposed Action, Action Alternative 1 and No Action Alternative 2). Maximum radiological impacts to the MEI for Action Alternative 2C and Action Alternative 3 would be a 1 percent chance of an LCF at ORNL.

Impacts to the maximally exposed noninvolved worker would range from a 0.1 percent chance of an LCF at Hanford for treatment to meet planning-basis WAC (Proposed Action, Action Alternative 1, and No Action Alternative 2) to a 3 percent chance of an LCF at Hanford for thermal treatment (Action Alternatives 2A and 2B and No Action Alternative 1). Thermal treatment at WIPP under Action Alternative 2C would have an impact of a 1 percent chance of an LCF to the maximally exposed noninvolved worker. Treatment by shred and grout (Action Alternative 3) would have a 2 percent chance of an LCF at Hanford.

Waste Storage Accidents

High-Frequency/Low-Consequence Accident (Container Drop, Puncture, and Lid Failure)

Maximum radiological impacts to the population from a high-frequency/low-consequence accident (a drum spill) for TRU waste treated to planning-basis WAC would be 5×10^{-4} LCFs at RFETS. (The annual frequency of occurrence of this accident would be 1×10^{-2}.) Maximum impacts due to thermally treated TRU waste and TRU waste treated by shred and grout would be 3×10^{-5} LCFs at RFETS.

Maximum radiological impacts to the MEI would be highest when storing TRU waste treated to the planning-basis WAC with a 3×10^{-5} percent chance of an LCF at ORNL. Maximum impacts to the MEI under thermal treatment and shred and grout treatment would be at LANL where a 8×10^{-7} percent chance of an LCF was estimated. Under Action Alternative 2C, impacts to the MEI at WIPP would be a 1×10^{-6} percent chance of an LCF.

Maximum radiological impacts to a maximally exposed noninvolved worker would be a 4×10^{-5} percent chance of an LCF at Hanford when storing TRU waste treated to the planning-basis WAC. Maximum impacts to the maximally exposed noninvolved worker would be the same for waste treated thermally or by a shred and grout process with a 2×10^{-6} percent chance of an LCF at Hanford and LANL. Under Action Alternative 2C, impacts to the maximally exposed noninvolved worker would be a 1×10^{-6} percent chance of an LCF.

Beyond-Design-Basis Accident (Collapse of Building Due to Earthquake)

Population impacts from a beyond-design-basis accident would range from 300 LCFs at RFETS (Action Alternative 1 and No Action Alternative 2) to 2 LCFs at Hanford (Proposed Action and Action Alternative 2C). Maximum impacts to the public under both thermal and shred and grout treatment (Action Alternatives 2A and 2B, Action Alternative 3, and No Action Alternative 1) would be 10 LCFs at RFETS.

Impacts to the MEI would range from a 7 percent chance of an LCF at RFETS (Action Alternative 1 and No Action Alternative 2) to a 0.03 percent chance of an LCF at WIPP (Action

Alternative 2C). Impacts to the MEI for Action Alternatives 2A and 2B, Action Alternative 3, and No Action Alternative 1 would be a 0.3 percent chance of an LCF at LANL. The impacts to the MEI under the Proposed Action were calculated to be a 0.06 percent chance of an LCF (Hanford).

Impacts for the maximally exposed noninvolved worker would be the greatest under Action Alternative 1 and No Action Alternative 2 with a 70 percent chance of an LCF at Hanford. The Proposed Action would have the fewest impacts with a 0.7 percent chance of an LCF at Hanford. There would be a 2 percent chance of an LCF at Hanford for both thermal treatment (Action Alternatives 2A and 2B and No Action Alternative 1) and shred and grout treatment (Action Alternative 3). Action Alternative 2C would have a 3 percent chance of an LCF at WIPP to the maximally exposed noninvolved worker.

WIPP Disposal Accidents

High-Frequency/Low-Consequence Accident (Container Drop, Puncture, and Lid Failure)

The maximum radiological impact to the population from a high-frequency/low-consequence accident (a drum spill), having an annual occurrence frequency of 0.1, would be greatest for TRU waste treated to the planning-basis WAC; the impact was estimated as 0.02 LCFs. Should the TRU waste be treated thermally or by a shred and grout process, the impact from this accident was estimated to be 9×10^{-4} LCFs to the public. The radiological impacts to the MEI would be highest when disposing of TRU waste treated to the planning-basis WAC; an estimated impact of 2×10^{-2} percent chance of an LCF was estimated. Should the waste be treated thermally or by a shred and grout process, the impact would be 1×10^{-3} percent chance of an LCF. The maximally exposed noninvolved worker would have a 2×10^{-2} percent chance of an LCF for such an accident involving TRU waste treated to the planning-basis WAC . For waste treated by a thermal or shred and grout process, the estimated impact to the maximally exposed worker would be a 1×10^{-3} percent chance of an LCF from the container-drop accident.

Low-Frequency/High-Consequence Accident (Failure of the Waste Shaft Hoist)

The impacts to the population from a hoist failure (maximum consequence accident) would be greatest under Action Alternatives 2A, 2B, and 2C and Action Alternative 3, with 24 LCFs. The Proposed Action and Action Alternative 1 would have an impact of 4 LCFs. The radiological impacts to the MEI would be a 40 percent chance of an LCF under Action Alternative 2 and Action Alternative 3, and a 7 percent chance of an LCF under the Proposed Action and Action Alternative 1. The maximally exposed noninvolved worker would have a 30 percent chance of an LCF under Action Alternative 2 and Action Alternative 3, and a 5 percent chance of an LCF under the Proposed Action and Action Alternative 1. Because the no action alternatives do not propose disposal activities, there would be no impacts to the public, MEI, or noninvolved worker as a result of these accidents.

Industrial Safety

The accident rate at DOE facilities is less than half the national average for industry, which means that DOE and its contractors experience considerably fewer injuries, illnesses, and fatalities than occur in private industry for similar work. For estimating WIPP impacts from operation and decommissioning, salt excavation activities were considered to be equivalent to construction activities which have a higher injury and illness rate than all other labor categories combined. SEIS-II analyses, therefore, are conservative.

During the 45 years of operation and decommissioning at WIPP under the Proposed Action two fatalities are projected to occur. The largest number of industrial safety fatalities would occur under Action Alternative 3, which would continue for 200 years (190 years for disposal and 10 years for decommissioning) and dispose of a greater amount of waste; it would result in seven fatalities.

Industrial safety fatalities from treatment under the Proposed Action would be four. The largest number of industrial safety fatalities due to treatment would be nine under Action Alternative 2A.

Long-Term Post-Closure Performance

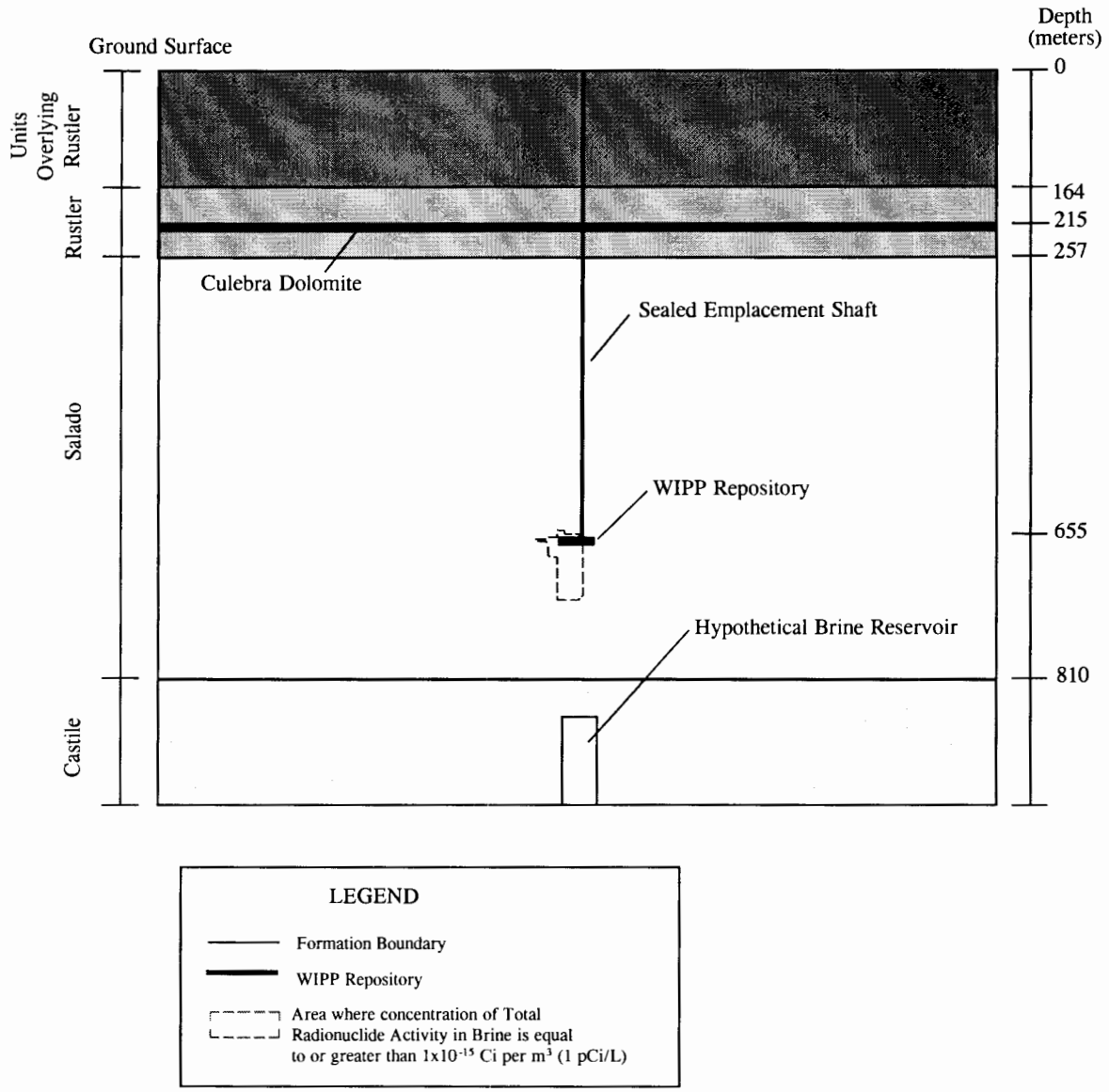
The performance of the WIPP repository was evaluated for the first 10,000 years following the decommissioning of the WIPP site. The performance assessment for WIPP evaluated the potential release of radioactive substances and the probability such substances would cause LCFs. The assessment also evaluated the probability of excess cancer incidence from releases of hazardous constituents, expressed as a hazard index. The analyses were conducted using median and 75th percentile parameter values selected from statistical distribution of modeling parameters for both undisturbed and disturbed conditions.

The analyses of undisturbed WIPP repository conditions for a period of 10,000 years following decommissioning indicate similar impacts under the Proposed Action and all of the action alternatives. No movement of brine- or gas-phase TRU waste beyond the 5 kilometers (3.1 miles) subsurface lateral boundary was predicted nor would there be any release to the Culebra Dolomite of the Rustler Formation, the principal water-bearing unit overlying WIPP (Figures S-5, S-6, S-7, and S-8). Thus, long-term undisturbed disposal of TRU waste at WIPP is not expected to contribute any impact to human health as long as the repository is not disturbed after decommissioning.

SEIS-II analyses also considered the impacts should a drilling crew drill into the repository. Impacts to a maximally exposed member of the drilling crew and a well geologist who participate in drilling the exploratory borehole were assessed. LCFs resulting from acute exposures of an MEI drilling crew member to CH-TRU and RH-TRU waste in drill cuttings ranged from 4×10^{-4} for the Proposed Action; 9×10^{-5} to 3×10^{-4} for Action Alternative 1; 5×10^{-4} to 7×10^{-5} for Action Alternative 2; and 9×10^{-5} to 3×10^{-4} for Action Alternative 3. LCFs resulting from acute exposure of a well site geologist to CH-TRU and RH-TRU wastes in drilling cuttings were 4×10^{-9} and 3×10^{-7} for the Proposed Action; 4×10^{-9} and 4×10^{-7} for Action Alternative 1; 1×10^{-8} and 1×10^{-6} for Action Alternative 2; and 3×10^{-9} and 3×10^{-7} for Action Alternative 3.

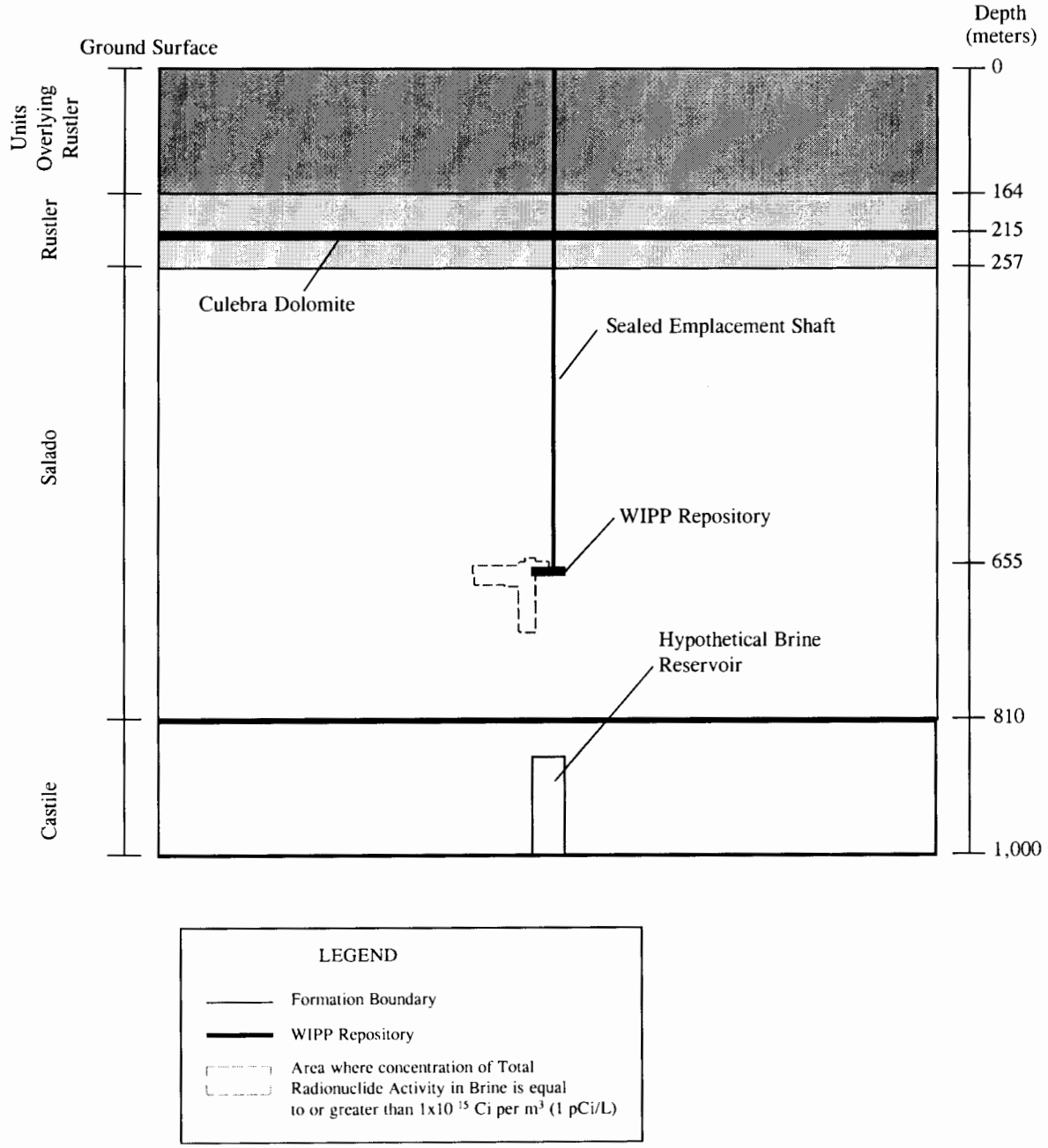
The impact of an exploratory borehole that penetrates the WIPP repository and a hypothetical pressurized brine reservoir also was evaluated. Analyses evaluated the potential for pressurized brine to enter the repository and move upward to overlying water-bearing units such as the Culebra Dolomite. Under such a scenario, the brine pressure would not be sufficient to transport waste to the overlying water-bearing units. Analysis of the Proposed Action and all action alternatives concluded that an intrusion with an exploratory borehole plugged using current practices would not lead to migration of radionuclides from the repository to overlying water-bearing units (Figure S-9).

At the storage sites under No Action Alternative 1, radionuclides and hazardous metals would be incorporated into a more dense and durable waste form that would limit the release of wastes into the accessible environment. VOCs would be removed in the treatment process and would not be



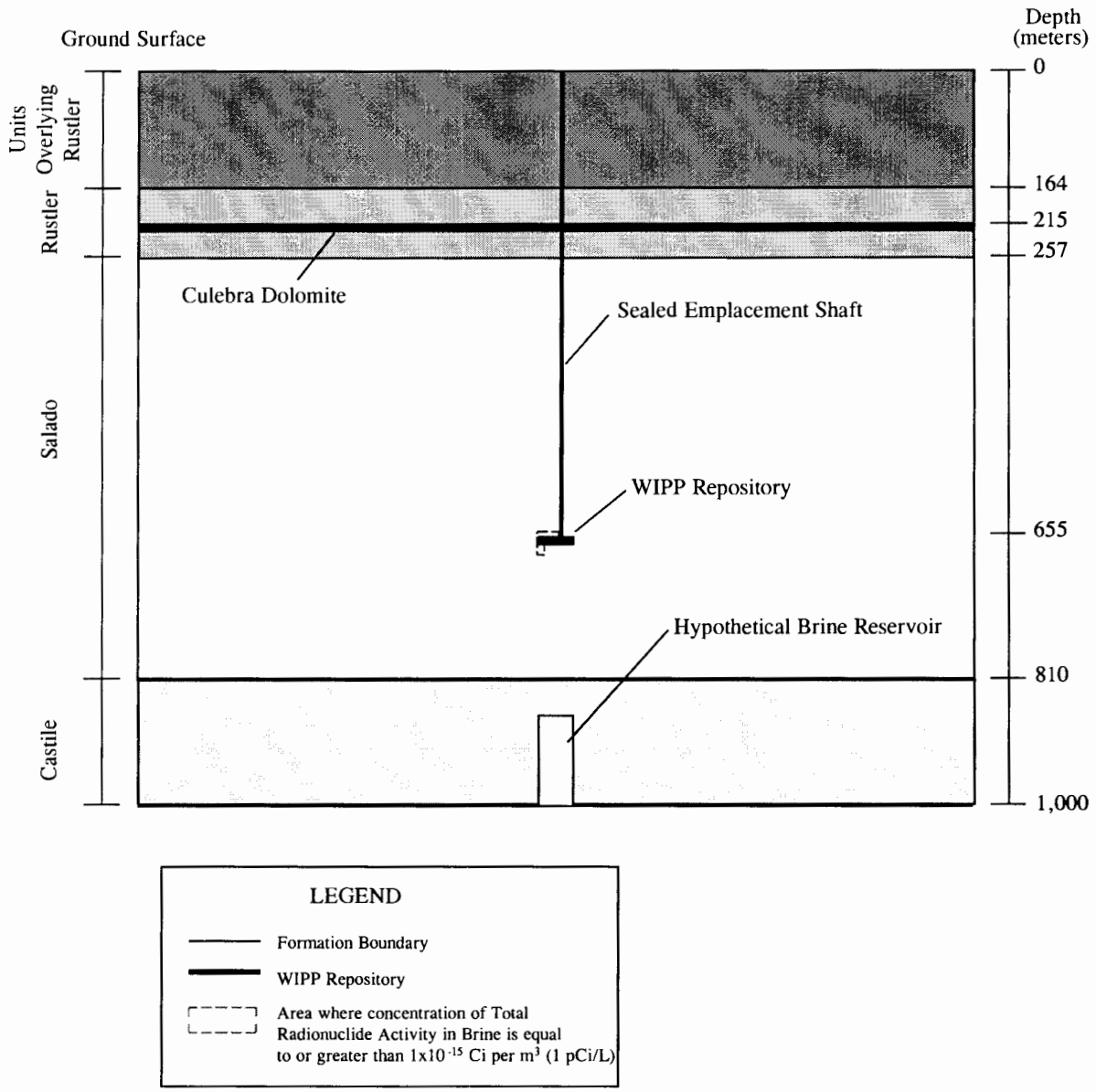
Note: Results show the area of concentration extending 60 meters (200 feet) below the repository, 10 meters (33 feet) above the repository, and 1,200 meters (3,940 feet) laterally from the edge of the repository.

Figure S-5
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions for the Proposed Action



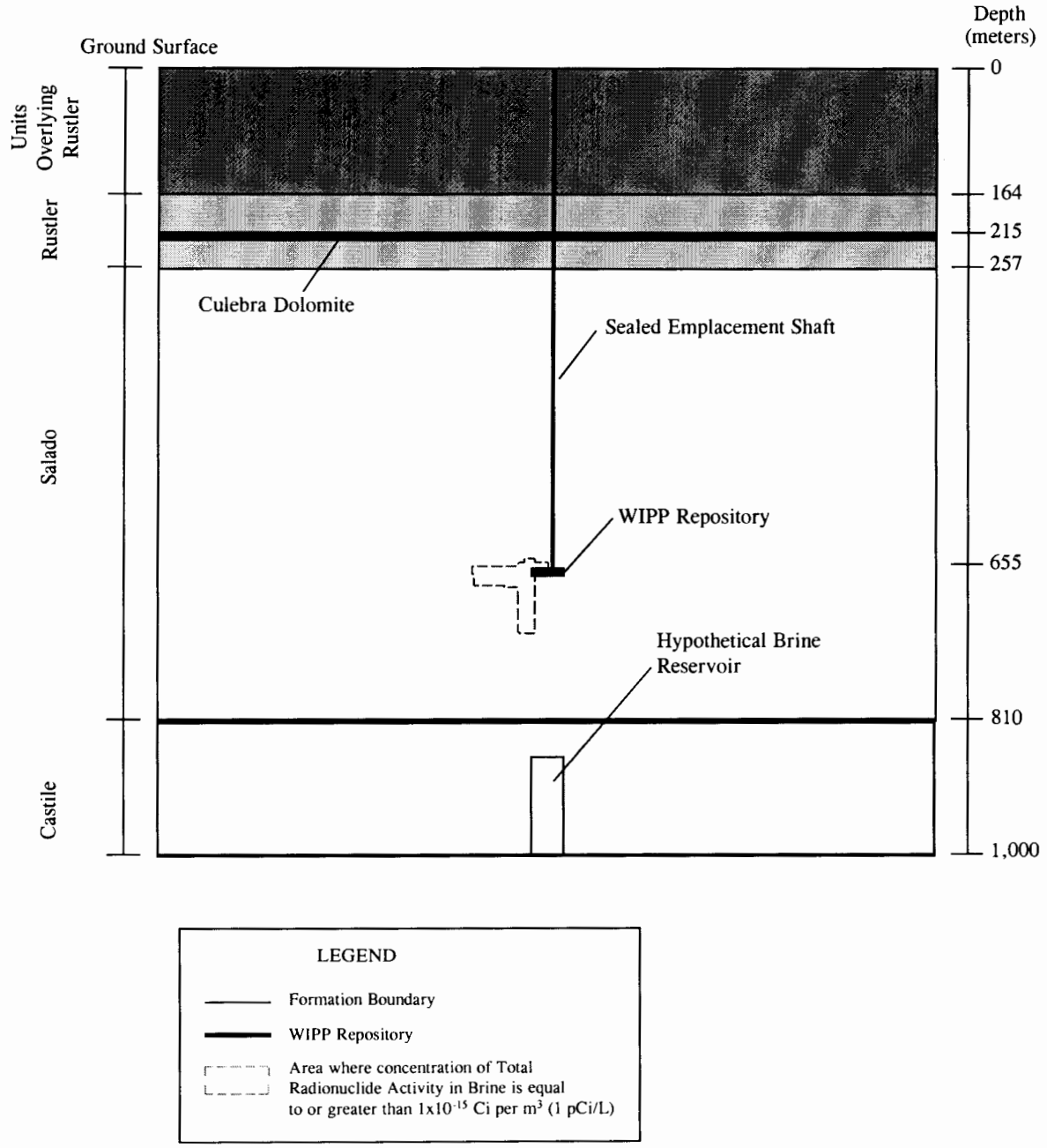
Note: Results show the area of concentration extending 60 meters (200 feet) below the repository, 15 meters (50 feet) above the repository, and 3,600 meters (11,800 feet) laterally from the edge of the repository.

Figure S-6
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions for Action Alternative 1



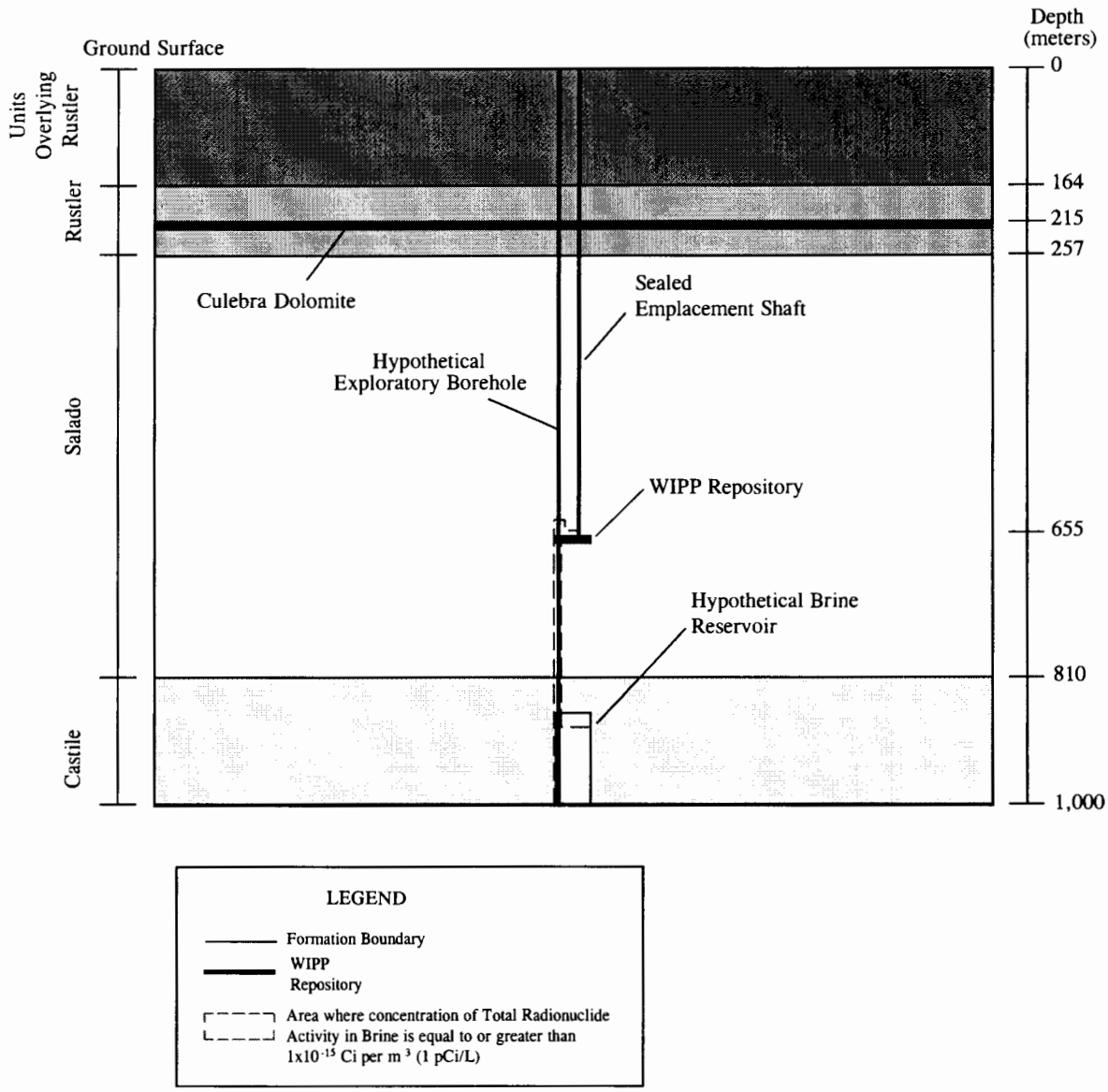
Note: Results show the area of concentration extending 15 meters (50 feet) below the repository, 7 meters (23 feet) above the repository, and 90 meters (295 feet) laterally from the edge of the repository.

Figure S-7
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions for Action Alternative 2 Subalternatives



Note: Results show the area of concentration extending 60 meters (200 feet) below the repository, 15 meters (50 feet) above the repository, and 3,600 meters (11,800 feet) laterally from the edge of the repository.

Figure S-8
Extent of Radionuclide Migration at 10,000 Years with Undisturbed Conditions for Action Alternative 3



Note: Results show the area of concentration extending upward 20 meters (66 feet) and downward to the Castile Formation and into the brine reservoir.

Figure S-9
Extent of Radionuclide Migration at 10,000 Years with Human Intrusion Conditions

present in emplaced waste. Once waste containers degrade, direct release from a thermally-treated waste form (e.g., metal slag or glass) would be controlled by corrosion and dissolution of metal or glass and natural forces responsible for erosion rather than the leaching process that controls radionuclide and metal contaminant releases from less competent waste forms.

Under No Action Alternative 2, the environmental and human health impacts were estimated at seven of the 10 major generator and storage sites. These sites include Hanford, INEL, LLNL, LANL, ORNL, RFETS, and SRS. The analysis focused on these seven major sites because 99 percent of the estimated waste volume and inventory will be generated and stored at these sites. Other sites considered but not examined in this analysis included ANL-E, Mound, and NTS.

The human health impacts of TRU waste were estimated for two types of exposures: (1) exposure from inadvertent human intrusion into areas of TRU waste storage and previously buried TRU waste, and (2) exposure from long-term source-term releases to surface and subsurface environmental exposure points. Analysis of intrusion for waste stored under the ground surface considered impacts of directly drilling into the wastes and gardening over the exhumed waste cuttings. Analysis of intrusion for waste stored aboveground considered impacts of an individual scavenging into the wastes and a farm family living over the wastes.

LCFs resulting from acute exposures to CH-TRU and RH-TRU wastes in drill cuttings ranged from 7×10^{-6} to 4×10^{-4} for a hypothetical drilling crew member and 2×10^{-4} to 4×10^{-3} for a hypothetical gardener over the seven sites analyzed. The aggregate impact to a gardener over 30 years ranged from 4×10^{-3} to 0.07 LCF. LCFs resulting from acute exposures to CH-TRU and RH-TRU wastes also ranged from 7×10^{-4} to 0.02 for a hypothetical scavenger and 0.2 to 7 for a hypothetical family farmer over the seven sites analyzed.

During any period of the 10,000 years, the estimated lifetime chance of an LCF to an MEI from environmental release of contaminants originating from buried and surface-stored wastes at the seven generator-storage sites ranged from 8 x 10-7 to 7 x 10-3. The highest LCF was estimated for RFETS.

The estimated lifetime population LCFs from exposure to contaminated air or surface water at each site ranged from 3×10^{-4} to 21. The highest impact (at the RFETS) was calculated as nearly 100 times higher than any other site. The aggregated impact from the seven sites over 10,000 years was estimated to result in 2,325 LCFs.

The maximum lifetime cancer incidence for exposed populations from hazardous chemicals was estimated to be less than 7×10^{-4} over the seven sites. The aggregated lifetime cancer incidence from the seven sites over 10,000 years was estimated at 0.25.

Retrieval and Recovery

For the purposes of SEIS-II, retrieval was defined as removing intact TRU waste containers before closure of WIPP. The calculations were based on retrieval of the waste from one full panel. For SEIS-II, recovery was defined as removal of all of the waste from the repository after closure and after the salt would have reconsolidated, breaching the TRU waste containers.

For the analysis of retrieval impacts, it was assumed that 17,560 cubic meters (620,000 cubic feet) of waste would be removed and transported back to its treatment site. The maximum aggregate LCF in the involved worker population was estimated as 0.03. No noncarcinogenic

effects would be expected, and impacts to the public and noninvolved workers would be smaller by at least an order of magnitude. Transportation impacts for returning the waste would be the same as for transporting it to WIPP. The total impacts would be about one-tenth the impacts of the Proposed Action.

For the analysis of recovery impacts, it was estimated that 3,370,000 cubic meters (119 million cubic feet) of waste and contaminated material would have to be removed, packaged, and shipped. Involved workers were assumed to be administratively limited to 1 rem per year. Based on 100 workers and a 35-year work period per worker, the total worker-population dose would be 3,500 person-rem. The total LCF in the involved worker population would be about 8. The total expectation of cancer incidence from exposure to hazardous chemicals would be smaller, on the order of 2×10^{-4}. No noncarcinogenic effects from exposure to hazardous chemicals would be expected. Health impacts to the public and to noninvolved workers would be expected to be three orders of magnitude (1,000 times) larger than the values presented for Alternative 3. For transportation impacts, the maximum radiological impacts have been calculated to occur from nonoccupational exposures resulting in an estimated 14 LCFs. Vehicle-related traffic fatalities have been calculated to increase to 213 due to a proportional increase in waste and transportation miles.

Environmental Justice

DOE is in the process of developing environmental justice guidance, pursuant to Executive Order 12898. This guidance will be finalized after stakeholder comments, concerns, and opinions are received, reviewed, and incorporated, as appropriate.[1] The approach taken in this SEIS-II analysis may depart somewhat from the guidance that is eventually issued or from the approach taken in other documents.

For purposes of this analysis, a high and adverse human health or environmental impact is a deleterious human health or environmental impact. A disproportionately high and adverse impact to a minority or low-income population is one that substantially exceeds the same type of impact in the larger community. A disproportionately high and adverse human health or environmental effect would occur when the human health risks are significant or the risk or rate to a minority or low-income population from exposure to an environmental or health hazard substantially exceeds the risk or rate to the general population.

The SEIS-II environmental justice analysis addresses the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations within an 80-kilometer (50-mile) area of the WIPP site. The shaded areas in Figures 4-7 and 4-8 show the percentage of minority populations and low income populations, respectively, in census blocks around the WIPP site. Minorities comprise about 36.8 percent of the population in the 80-kilometer (50-mile) area around WIPP, and low-income individuals about 21.5 percent of this population.

The populations within an 80-kilometer (50-mile) area of the other treatment sites are described in Chapter 4 of SEIS-II. SEIS-II also incorporates by reference the maps of the census tracts containing greater than 50 percent minority and low-income populations within the 80-kilometer (50-mile) area of treatment sites that are included in Appendix I of the Draft WM PEIS. Of note

[1] The Council on Environmental Quality has also developed draft "Guidance for Addressing Environmental Justice Under the National Environmental Policy Act."

for environmental justice assessments are LANL and SRS, where minorities constitute greater than 55 percent and 35 percent, respectively, of the total populations within the 80-kilometer (50-mile) area.

For treatment, potentially high and adverse human health effects could occur during normal, accident-free treatment operations at some treatment sites as a result of TRU waste management activities under the three Action Alternative 2 subalternatives. Several segments of the population in the vicinity of WIPP contain a greater percentage of minorities than some areas within the 80-kilometer (50-mile) area of WIPP and the population of the United States as a whole. It is possible, therefore, that adverse health impacts (estimate of 1 fatality) from routine or accident-free thermal treatment of waste at WIPP under Action Alternative 2C would disproportionately affect the minority populations in the vicinity of WIPP. The prevailing winds at both SRS and LANL would direct treatment releases away from the concentrations of minority and low-income populations that exist around those sites. At all treatment sites, treatment accidents would be unlikely so that accidents would not be expected to impact off-site populations; also the impacts from treatment accidents would depend on meteorological conditions at the time of the accident. For these reasons, it is not likely that adverse environmental or human health impacts would disproportionately affect the minority or low-income populations at any of the treatment sites.

Potentially high and adverse impacts as defined above may occur as a result of waste transportation activities. Routine transportation could cause up to 15 public fatalities over the life of the project from radiation exposure primarily to the population near locations where trucks routinely stop. Up to 303 fatalities could occur from traumatic injuries sustained in accidents involving transportation vehicles. Severe transportation accidents that breach the transport package could result from 16 to 32 LCFs under any alternative. However, accidents would be random events that could occur on any segment of the transportation route and thus would not be likely to disproportionately affect minority or low-income populations.

For disposal at WIPP, normal accident-free operations would not cause significant adverse human health or environmental impacts, and thus there would be no such impacts that could disproportionately affect minority or low-income populations. For disposal accidents, the most severe accident (the waste hoist failure) could cause up to 4 public fatalities for the Proposed Action and up to 24 fatalities for Action Alternative 3. However, the annual probability of this accident is 4.5×10^{-7}. Therefore, although possible, disproportionately high and adverse effects on minority or low-income populations would not be expected.

SUMMARY OF IMPACTS

Over the life of campaign, routine operations under the Proposed Action could result in an estimated six worker fatalities at waste treatment sites and three worker fatalities at WIPP. Truck transportation under the Proposed Action could result in an estimated additional nine deaths among members of the public and crew. Although highly unlikely, the most severe accident, a severe truck accident with a maximum radionuclide inventory having a frequency of less than 7.5×10^{-7}, could result in an additional 16 deaths. The waste disposed of at WIPP under the Proposed Action would be isolated from the environment for more than 10,000 years. However, the Proposed Action would leave the excess RH-TRU waste (from the Basic Inventory) and about half of the total TRU waste volume (from the Total Inventory) in storage, and subject to release if DOE were to lose institutional control of the sites where it was stored. Health impacts due to any released waste at the storage sites could vary depending on the population density in the vicinity at the time

the waste were released. The Proposed Action would be the least expensive of the action alternatives ($19.1 billion in 1994 dollars, $10.1 billion when the costs are discounted).

Action Alternative 1 could result in an estimated seven worker fatalities at the waste treatment sites and seven worker fatalities at WIPP. Truck transportation under Action Alternative 1 could result in an estimated additional 32 deaths (31 among members of the public). The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 300 deaths. The waste disposed of at WIPP under Action Alternative 1 would be isolated from the environment for more than 10,000 years, and Action Alternative 1 would effectively isolate all DOE TRU waste (except for a small quantity of PCB-commingled waste). Action Alternative 1 costs would be $50.5 billion in 1994 dollars ($16.3 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

Action Alternative 2 could result in an estimated 9 to 14 worker fatalities at the waste treatment sites and one to five fatalities to the populations in the vicinity of the treatment sites (with subalternatives 2A and 2B having higher impacts than subalternative 2C). An estimated six worker fatalities would result from disposal operations at WIPP under all subalternatives. Truck transportation under Action Alternative 2 could result in an estimated additional 14 to 19 deaths (14 to 18 among members of the public, with Action Alternative 2C having higher transportation impacts than Action Alternatives 2A or 2B). The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 30 deaths. The waste disposed of at WIPP under Action Alternative 2 would be isolated from the environment for more than 10,000 years, and Action Alternative 2 would effectively isolate all DOE TRU waste. Action Alternative 2 costs would range from $53.2 billion to $56.9 billion in 1994 dollars ($19.2 billion to $20.8 billion when discounted), depending on subalternative and assuming truck transportation (to be comparable to the Proposed Action).

Action Alternative 3 could result in an estimated nine worker fatalities at the waste treatment sites and seven worker fatalities at WIPP. Truck transportation under Action Alternative 3 could result in an estimated additional 41 deaths (40 among members of the public). The most severe accident under this alternative would be the failure of the WIPP waste hoist (with an annual frequency of 4.5×10^{-7} or less) and could result in an additional 24 deaths. The waste disposed of at WIPP under Action Alternative 3 would be isolated from the environment for more than 10,000 years, and Action Alternative 3 would effectively isolate all DOE TRU waste (except for a small quantity of PCB-commingled waste). Action Alternative 3 costs would be $59.7 billion in 1994 dollars ($18.3 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

No Action Alternative 1 could result in an estimated 12 to 14 worker fatalities at the waste treatment sites and three to five fatalities to the populations in the vicinity of the treatment sites (depending on the subalternative). No worker deaths would be estimated to result from closure activities at WIPP. Truck transportation under No Action Alternative 1 could result in an estimated zero to two deaths to members of the public. The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 30 deaths. No Action Alternative 1 would restrict access to all DOE TRU waste for 100 years, at which time the waste would either have to be disposed of or a decision would have to be made to continue storage. If the waste were released, either by loss of institutional control or by natural

disaster, the thermally treated waste form would restrict migration of the waste initially, but the waste would eventually become more mobile as the vitrified waste form eroded. If the waste were released, deaths to the public over 10,000 years would depend in part on population densities and distributions, but would be expected to be less than the 2,325 fatalities anticipated for No Action Alternative 2. Future increases in population densities near TRU waste storage sites could increase the number of estimated deaths that could result from releases of TRU waste. No Action Alternative 1 costs would range from $28.6 to $31.6 billion in 1994 dollars ($16 to $18 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

No Action Alternative 2 could result in an estimated two worker fatalities at the waste storage sites and no worker deaths from closure activities at the WIPP site. No transportation is assumed under No Action Alternative 2, and no deaths would result. The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 300 deaths. No Action Alternative 2 would restrict access to the currently stored and newly generated portion of DOE TRU waste for 100 years, at which time the waste would either have to be disposed of or a decision would have to be made to continue storage. If the waste were released, either by loss of institutional control or by natural disaster, estimated deaths would total 2,325 over 10,000 years given current population densities and distributions. Future increases in population densities near TRU waste storage sites could increase the number of estimated deaths that could result from releases of TRU waste. No Action Alternative 2 costs would be $2.7 billion in 1994 dollars ($1.8 billion when discounted).

Table S-7 summarizes the results of SEIS-II analyses.

Table S-7
Summary of SEIS-II Environmental Impacts

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Land Use and Management									
Treatment Facility Sites	No substantial impacts identified beyond the treatment facilities. Treatment facilities would require no more than 11 hectares, less than 1% of land available at each site for each alternative. Treatment facilities, therefore, could be located in developed areas or areas appropriate for development. Sensitive areas, including wetlands, flood plains, sensitive habitats, and cultural resource areas would be avoided.								No substantial impacts. Only newly generated waste would be treated. No new treatment facilities would be constructed.
WIPP (during operations)	DOE would occupy the land transferred by the LWA and lease some other land. WIPP would continue to limit drilling and mining activities, and grazing and public access to the site. No other impacts would occur to local land use beyond the site.						Impacts would be minimal because no waste would be emplaced.		
WIPP (area impacted by closure)	60 hectares	295 hectares	324 hectares	324 hectares	324 hectares	307 hectares	20 hectares	20 hectares	20 hectares
Air Quality									
Treatment Facility Sites (Emissions for sites and pollutants not specifically noted would be less than 10% of the most stringent applicable regulatory standard).	RFETS, CO, 17%.		RFETS, radionuclides, 134%. SRS, radionuclides, 48%. RFETS, CO, 24%. INEL, PM_{10} 10%.	INEL, radionuclides, 10%. SRS, radionuclides, 48%. INEL, PM_{10}, 10%.	WIPP, radionuclides, 319%. WIPP, SO_2, 12%. WIPP, PM_{10}, 25%.	RFETS, CO, 20%.	RFETS, radionuclides, 134%. SRS, radionuclides, 48%. RFETS, CO, 24%, INEL, PM_{10}, 10%.	INEL, radionuclides, 10%. SRS, radionuclides, 48%. INEL, PM_{10}, 10%.	No substantial impacts identified. Only minimal treatment would occur.
WIPP Operations (percent of applicable EPA or state standard)	Annual average: negligible increases of O_3 and lead; less than 2% increases in PM_{10}, NO_2, and SO_2. Short-term (24-hour) emission limits: PM_{10} - 57%, NO_2 - 65%, SO_2 - 7%, CO - 3% of standards, releases of lead and ozone would be minimal.						WIPP would not be operated. WIPP would be dismantled.		
Biological Resources									
Treatment Facility Sites	Threatened and endangered species appear at many of the proposed treatment sites and could potentially be impacted. Such species and their critical habitats would be avoided through appropriate consultation, site selection, monitoring, and mitigation measures. Because the treatment sites would require less than 1% of the land available at any site, critical habitats could be avoided at most sites.								No impacts because only minimal treatment would occur.
WIPP (disturbed land area)	Federally- or state-listed or protected, threatened, endangered, and proposed species occur in Eddy County and potentially at the WIPP site, although there have been no threatened, endangered, or proposed species or critical habitats recently observed at the WIPP site by DOE during completion of its recent biennial environmental compliance reports. DOE is conducting new biological surveys at the WIPP site. DOE will prepare a biological assessment and consult with federal and state agencies as appropriate, and include such information in the Final SEIS-II. No impacts to biodiversity or ecosystem balance would be expected. Impacts to other plant and animal species may occur during closure and construction of a berm around the WIPP site. The affected area would differ based on the areas listed above under land use.						Minimal impacts during closure of current facility.		

Table S-7
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Cultural Resources									
Treatment Facility Sites	Although cultural resources are present at many sites, specific treatment facility locations are unknown. Acreage need at any one site is 11 hectares or less. Potential impacts will be avoided or mitigated based on site-specific cultural resource surveys.								No impacts. Treatment would be minimal.
WIPP Resource Sites Potentially Impacted (during operations)	None.						No impacts. WIPP would not be operated.		
WIPP Resource Sites Potentially Impacted (during closure)	Two.	Eleven due to larger surface closure area.					No impacts for the no action alternatives. Closure would only involve the 20 acres on which current facilities have been built.		
Noise									
Treatment Sites	Negligible increase in noise due to waste transportation or treatment facility operation because treatment facilities would probably be placed at industrial-type sites along high-traffic volume corridors. Project-specific impacts to sensitive receptors could occur. Assessment of potential impacts would be conducted in site-wide or project-specific NEPA documentation.								No impacts because transportation would not occur and treatment would be minimal.
WIPP	Negligible increase in noise due to additional daily truck or train traffic. Only 8 trucks per day would travel to WIPP if trucks are used; only 13 to 16 rail cars per week if trains are used.						Not applicable to the no action alternatives. No transportation to WIPP would occur and WIPP would not be operated.		
Water Resources and Infrastructure									
Treatment Sites 1. Water 2. Power 3. Wastewater 4. On-site Transportation	3. Hanford - 5.9% 4. Hanford, INEL, and LANL - minor impacts		2. INEL - 7% 3. Hanford - 7.8% 4. Hanford, INEL, and LANL - minor impacts	2. INEL - 7% 3. Hanford - 7.8% 4. Hanford, and INEL - minor impacts	2. INEL - 7%; WIPP - 50% 3. WIPP - 80% 4. WIPP - 162%; Hanford - minor impacts	2. INEL - 6.4% 3. Hanford - 7% 4. Hanford, INEL, and LANL - minor impacts	2. INEL - 7% 3. Hanford - 7.8% 4. Hanford, INEL, and LANL - minor impacts	2. INEL - 7% 3. Hanford - 7.8% 4. Hanford, and INEL - minor impacts	No impacts.
Disposal Operations at WIPP	Annual incremental infrastructure impacts at WIPP would be negligible and within capacity for disposal operations.						Decreasing use of resources, none after decommissioning of WIPP.		

Table S-7
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Socioeconomics									
Treatment/Storage Sites									
Life-Cycle Costs (millions of 1994 dollars)	11,800	21,400	27,700	30,000	28,700	24,400	27,300	27,700	1,908
Employment (additional ROI jobs - direct, indirect, and induced)	5,700	11,700	15,700	15,500	10,600	13,300	15,700	15,500	800
Disposal Operations at WIPP									
Life-Cycle Costs (millions of 1994 dollars)	5,300	24,600	23,300	23,300	23,300	28,500	850	850	850
Goods & Services (millions of 1994 dollars)	17,700	80,800	75,800	75,800	147,000	96,000	-524	-524	-524
Employment (job-years)	118,000	539,400	505,700	505,700	982,700	640,500	-3,370	-3,370	-3,370
Labor Income (millions of 1994 dollars)	4,200	19,200	18,000	18,000	35,000	22,800	-120	-120	-120
Total Life-Cycle Cost by Mode of Transportation (millions of 1994 dollars); discounted totals using a 4.1 percent annual inflation rate are presented in parentheses									
Total Life-Cycle Costs--Truck	19,100 (10,100)	50,500 (16,300)	53,200 (19,400)	56,300 (20,800)	56,900 (20,400)	59,700 (18,300)	28,600 (16,000)	31,600 (18,000)	No shipments of TRU waste would occur under this alternative. Total life-cycle cost without transportation is 2,800.
Total Life-Cycle Costs--Regular Rail	No rail transportation analyzed in this alternative.	47,500 (15,800)	51,600 (19,200)	54,700 (20,600)	53,200 (19,800)	55,000 (17,700)	28,600 (15,900)	31,500 (18,000)	
Total Life-Cycle Costs--Dedicated Rail		57,300 (17,300)	56,000 (19,900)	59,400 (21,400)	61,800 (21,300)	68,500 (19,500)	28,800 (16,100)	32,600 (18,500)	
Transportation									
Truck									
Number of Truck Shipments to Consolidation Sites and WIPP	CH - 29,766 RH - 7,957	CH - 41,003 RH - 62,162	CH - 25,363 RH - 21,895	CH - 25,361 RH - 21,895	CH - 41,151 RH - 21,895	CH - 67,309 RH - 74,606	CH - 485 RH - 1,681	CH - 8,413 RH - 1,681	No shipments of TRU waste would occur under this alternative.
Nonradiological Truck Impacts									
Truck Accidents	76	237	107	114	140	331	3	14	
Truck Injuries	48	148	66	69	87	208	0	13	
Truck Fatalities	6	19	9	9	12	25	0	1	
Truck Pollution Fatalities	0.2	0.5	0.2	0.3	0.3	0.7	5.0E-3	0.04	

Table S-7
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Radiological Truck Impacts									No shipments of TRU waste would occur under this alternative.
Accident-Free Population Impacts to Crews (LCFs)	0.3	0.7	0.4	0.4	0.6	1.0	5.2E-3	0.07	
Accident-Free Population Impacts to the Public (LCFs)	3.0	11	5	5	6	14	0.1	0.5	
Highest Lifetime Accident-Free Impact to MEIs (probability of an LCF)	3.3E-3	8.1E-3	7.0E-3	7.0E-3	7.1E-3	7.0E-3	Not Analyzed.	Not Analyzed.	
Rail									
Number of Rail Shipments to WIPP	Transportation by rail not included in this alternative.	CH - 20,502 RH - 31,081	CH - 12,682 RH - 10,948	CH - 12,681 RH - 10,948	CH - 20,576 RH - 10,948	CH - 33,655 RH - 37,303	CH - 243 RH - 841	CH - 4,207 RH - 841	
Nonradiological Rail Impacts									
Fatalities Using Regular Rail Service		9	4	4	5	13	0.09	0.6	
Fatalities Using Dedicated Rail Service		216	97	103	127	303	2	16	
Radiological Rail Impacts									
Accident-Free Population Impacts to Crews (Regular and Dedicated) (LCFs)		0.03	0.02	0.02	0.03	0.5	3.2E-4	3.2E-3	
Accident-Free Population Impacts to the Public (Regular and Dedicated) (LCFs)		1.4	0.7	0.7	0.8	1.9	0.02	0.08	
Accidents									
Transportation Accidents (Truck)									
Population Impacts with Conservative Inventory (LCFs)	CH - 16 RH - 16	CH - 16 RH - 16	CH - <1 RH - <1	CH - <1 RH - <1	CH - 16 RH - <1	CH - 16 RH - 16	CH - 16 RH - 16	CH - 16 RH - 16	
Population Impacts with Average Inventory (LCFs)	CH - 3 RH - 0.04	CH - 3 RH - 0.04	CH - <1 RH - <1	CH - <1 RH - <1	CH - 3 RH - <1	CH - 3 RH - 0.04	CH - 3 RH - 0.04	CH - 3 RH - 0.04	
MEI Impact with Conservative Inventory (probability of an LCF)	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	CH - 2E-4 RH - 2E-4	CH - 2E-4 RH - 2E-4	CH - 0.06 RH - 2E-4	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	
MEI Impact with Average Inventory (probability of an LCF)	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	CH - 2E-4 RH - 2E-6	CH - 2E-4 RH - 2E-6	CH - 0.04 RH - 2E-6	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	
Aggregate Potential Truck Accident Impacts to Populations Along All Transportation Routes (LCFs)	0.4	0.8	0.4	0.4	0.7	1.2	6.8E-3	0.02	

Table S-7
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Transportation Accidents (Rail)									No shipments of TRU waste would occur under this alternative.
Population Impacts with Conservative Inventory (LCFs)	No rail transportation is proposed under the Proposed Action.	CH - 32 RH - 32	CH - <1 RH - <1	CH - <1 RH - <1	CH - 32 RH - <1	CH - 32 RH - 32	CH - 32 RH - 32	CH - 32 RH - 32	
Population Impacts with Average Inventory (LCFs)		CH - 6 RH - 0.08	CH - <1 RH - <1	CH - <1 RH - <1	CH - 6 RH - <1	CH - 6 RH - 0.08	CH - 6 RH - 0.08	CH - 6 RH - 0.08	
MEI Impact with Conservative Inventory (probability of an LCF)		CH - 0.12 RH - 0.12	CH - 4E-4 RH - 4E-4	CH - 4E-4 RH - 4E-4	CH - 0.12 RH - 4E-4	CH - 0.12 RH - 0.12	CH - 0.12 RH - 0.12	CH - 0.12 RH - 0.12	
MEI Impact with Average Inventory (probability of an LCF)		CH - 0.08 RH - 1E-3	CH - 3E-4 RH - 4E-6	CH - 3E-4 RH - 4E-6	CH - 0.08 RH - 4E-6	CH - 0.08 RH - 1E-3	CH - 0.08 RH - 1E-3	CH - 0.08 RH - 1E-3	
Aggregate Potential Rail Accident Impacts (LCFs) to Populations Along All Rail Routes		0.8	0.4	0.4	0.7	1.2	6.8E-3	0.02	
Human Health									
Routine Radiological Impacts (LCFs)[a]									
Treatment									
Involved Worker Population	2	3	5	5	3	4	5	5	8E-2
Noninvolved Worker Population Maximum Exposed Noninvolved Worker	2E-5 7E-9	2E-5 8E-9	0.5 3E-4	0.3 2E-4	0.09 3E-4	4E-5 2E-8	0.5 3E-4	0.3 2E-4	2E-5 7E-9
Public Population MEI	2E-4 9E-9	2E-4 1E-8	5 9E-5	3 2E-5	1 3E-4	4E-4 2E-8	5 9E-5	3 2E-5	2E-4 9E-9
***WIPP Operations[b]* (LCFs)[a]**							**Storage Impacts at Treatment Sites Only - No WIPP Operations**		
Involved Worker Population	0.6	0.8	0.2	0.2	0.2	0.2	0.4	0.4	1
Noninvolved Worker Population Maximum Exposed Noninvolved Worker	4E-4 4E-7	4E-4 4E-7	2E-4 2E-7	2E-4 2E-7	2E-4 2E-7	3E-4 3E-7	2E-2 1E-6	2E-2 1E-6	4E-2 4E-5
Public Population MEI	3E-4 3E-7	3E-4 5E-7	5E-5 1E-7	5E-5 1E-7	5E-5 1E-7	2E-4 3E-7	1E-3 2E-7	7E-4 2E-9	1E-2 2E-6
Lag Storage[c] Public Population Impacts Lag Storage Noninvolved Worker Population	No lag storage for the Proposed Action.	1E-2 4E-2	1E-3 2E-2	6E-4 2E-2	1E-4 4E-4	2E-3 4E-2	No lag storage for the no action alternatives.		
Excess RH-TRU Waste Storage Public Population Impacts Excess RH-TRU Waste Storage Noninvolved Worker Population	2E-5 4E-5	No excess RH-TRU waste is considered in these alternatives; such RH-TRU waste is reflected in the inventory/waste volumes for these alternatives.							

Table S-7
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Routine Hazardous Chemical Impacts (Cancer Incidence)									
Treatment at Treatment Sites									
Involved Worker Population	4E-5	6E-5	2E-4	2E-4	4E-4	1E-4	2E-4	3E-4	4E-6
Noninvolved Worker Population	1E-7	1E-7	1E-7	1E-7	1E-7	3E-7	1E-7	1E-7	1E-7
Maximum Exposed Noninvolved Worker	5E-11	5E-11	4E-11	4E-11	4E-11	5E-11	4E-11	4E-11	5E-11
Public Population	4E-7	4E-7	4E-7	3E-5	5E-7	8E-7	4E-7	3E-7	4E-7
Maximum Exposed Individual	8E-12	8E-12	7E-12	6E-12	9E-12	1E-11	7E-12	7E-12	8E-12
WIPP Operations[a]							**Storage Impacts at Treatment Sites Only - No WIPP Operations**		
Involved Worker Population	1E-2	3E-2	No impacts because the TRU waste would be thermally treated.			7E-3	None because TRU waste would be thermally treated.		4E-2
Noninvolved Worker Population	1E-4	1E-4				5E-5			2E-3
Maximum Exposed Noninvolved Worker	1E-7	9E-8				5E-8			2E-7
Public Population	2E-5	2E-5				1E-5			2E-3
Maximum Exposed Individual	3E-8	2E-8				1E-8			4E-8
Lag Storage[c] Public Population	No lag storage for the Proposed Action.	3E-3				2E-3	None because there is no lag storage for the no action alternatives.		
Lag Storage Noninvolved Worker Population		5E-3				9E-3			
Excess RH-TRU Waste Storage Public Population Impacts	3E-4	No excess RH-TRU waste is considered in these alternatives; such RH-TRU waste is reflected in the inventory/waste volumes for these alternatives.							
Excess RH-TRU Waste Storage Noninvolved Worker Population	6E-4								
Selected Facility Accidents[a]									
Treatment Facility Sites (Earthquake) LCFs									
Maximally Exposed Noninvolved Worker	1E-3	1E-3	0.03	0.03	0.01	0.02	0.03	0.03	1E-3
Maximally Exposed Individual	8E-4	8E-4	0.02	0.02	0.01	0.01	0.02	0.02	8E-4
Public Population	1	1	30	30	1	10	30	30	1
Storage Facility Sites (Earthquake) LCFs									
Maximally Exposed Noninvolved Worker	7E-3	0.7	0.02	0.02	0.03	0.02	0.02	0.02	0.7
Maximally Exposed Individual	6E-4	0.07	3E-3	3E-3	3E-4	3E-3	3E-3	3E-3	0.07
Public Population	2	300	10	10	2	10	10	10	300
WIPP Disposal (Hoist Failure, frequency of 4.5E-7) LCFs									
Maximally Exposed Noninvolved Worker	0.05	0.05	0.3	0.3	0.3	0.3	No impacts because disposal does not occur under the no action alternatives.		
Maximally Exposed Individual	0.07	0.07	0.4	0.4	0.4	0.4			
Public Population	4	4	24	24	24	24			

Table S-7
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Industrial Safety									
Waste Treatment (fatalities)	4	4	9	7	6	5	9	7	0.7
Construction and Operations (fatalities)	2	6	6	6	6	7	0.4	0.4	0.6
Performance Assessment of Treatment Sites and WIPP									
Treatment Sites - Human Intrusion									
Radiological Impacts (probability of an LCF)									
Drilling Crew Member	Does not apply to these alternatives because there is no waste at the treatment sites under the Proposed Action and the action alternatives, and TRU waste is managed indefinitely under No Action Alternatives 1A and 1B.								7E-6 to 4E-4
Gardener									4E-3 to 0.07
Scavenger									7E-4 to 0.02
Family Farm									> 1
Environmental Release									
MEI (probability of an LCF)	8.5E-4	Does not apply to these alternatives because there is no waste at the treatment sites under the Proposed Action and the action alternatives. For No Action Alternatives 1A and 1B, it was assumed the waste would be managed forever.							8E-7 to 7E-3
Population (LCFs)	<2								3E-4 to 21
Aggregate Population Impacts over 10,000 years	<0.9 due to excess RH-TRU waste[d]	Does not apply to these alternatives because there is no waste at the treatment sites.					Less than No Action Alternative 2[e]	Less than No Action Alternative 2[e]	2,325
Hazardous Chemical Impacts									
Environmental Release (Cancer Incidence)									
MEI	Does not apply to these alternatives because there is no waste at the treatment sites under the Proposed Action and the action alternatives, and TRU waste is managed indefinitely under No Action Alternative 1.								2E-7 to 5E-3
Population									8E-9 to 7E-4
WIPP - Human Intrusion (based on the intrusion in the repository scenario)									
Radiological Impacts Drilling Crew Member (probability of an LCF; dashes indicate no analyses were performed because scenarios are inapplicable)									
CH-TRU Waste Panel	---	3E-4	5E-4	5E-4	5E-4	2E-4	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
RH-TRU Waste Panel	---	9E-5	7E-5	7E-5	7E-5	9E-5			
Mixed CH-TRU and RH-TRU Panel	4E-4	3E-4	---	---	---	3E-4			
Radiological Impacts Site Geologist (probability of an LCF)									
CH-TRU Waste Panel	4E-9	4E-9	1E-8	1E-8	1E-8	3E-9	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
RH-TRU Waste Panel	3E-7	4E-7	1E-6	1E-6	1E-6	3E-7			
Hazardous Chemical Impacts (Cancer Incidence)									
Intruder (fraction of IDLH value)	4E-3	4E-3	5E-4	5E-4	5E-4	1E-3	Does not apply to these alternatives. No waste would be disposed of at WIPP.		

Table S-7
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Environmental Justice									
Treatment sites and WIPP	Although possible, disproportionately high and adverse effects on minority or low-income populations are not expected.				Impacts are possible at WIPP during treatment.	Although possible, disproportionately high and adverse effects on minority or low-income populations are not expected.			
TRU Waste Retrieval (of one panel of waste before repository closure)									
Population Exposures (LCFs)									
Involved Worker Population	0.03	0.03	0.03	0.03	0.03	0.03	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Noninvolved Worker Population	1E-3	1E-3	1E-3	1E-3	1E-3	1E-3			
Public Population	3E-5	3E-5	3E-5	3E-5	3E-5	3E-5			
Transportation									
Occupational	0.03	0.03	0.03	0.03	0.03	0.03	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Nonoccupational	0.3	0.3	0.3	0.3	0.3	0.3			
Vehicle-Related Fatalities	0.5	0.5	0.5	0.5	0.5	0.5			
TRU Waste Recovery (of all waste after repository closure)									
Population Exposures (LCFs)									
Involved Worker Population	8	8	8	8	8	8	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Noninvolved Worker Population	0.3	0.3	0.3	0.3	0.3	0.3			
Public Population	0.2	0.2	0.2	0.2	0.2	0.2			
Transportation									
Occupational Fatalities	1	1	1	1	1	1	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Nonoccupational Fatalities	14	14	14	14	14	14			
Pollution-Health Effects Fatalities	6	6	6	6	6	6			
Vehicle-Related Fatalities	213	213	213	213	213	213			

[a] The probability of an LCF occurring to the MEI or maximum exposed noninvolved worker, and the number of LCFs to the populations.
[b] Under the no action alternatives, this category represents impacts from storage.
[c] Lag storage is storage pending shipment to WIPP. Lag storage does not include long-term storage of waste (such as excess RH-TRU waste under the Proposed Action) that will not be shipped to WIPP.
[d] Results are based on the analysis of No Action Alternative 2.
[e] If institutional control were lost, fatalities would be expected although the LCFs would be less than No Action Alternative 2.

CHAPTER 1

CHAPTER 1
INTRODUCTION

This chapter presents the underlying purpose and need for action, the National Environmental Policy Act (NEPA) compliance history for the Waste Isolation Pilot Plant (WIPP), the need for the second supplemental environmental impact statement (SEIS-II), the relationship of SEIS-II to other planning documents, and a description of the contents of this document.

1.1 PURPOSE AND NEED FOR ACTION

The U.S. Department of Energy (DOE or the Department) needs to dispose of transuranic (TRU) waste generated by past, present, and future activities in a manner that protects public health and the environment. In previous NEPA documents, the Department examined alternatives to repository disposal at WIPP. In this document, the Department assesses whether and, if so, how to dispose of TRU waste at WIPP.[1]

1.2 OVERVIEW

TRU waste has been generated since the 1940s as part of the nuclear defense research and production activities of the federal government. Several types of operations (current, past, or future) have generated or will generate TRU waste: (1) nuclear weapons development and manufacturing, (2) plutonium recovery, stabilization, and management, (3) research and development, (4) environmental restoration, and decontamination and decommissioning, (5) waste management, and (6) testing at private institutions and universities under DOE contract.

Until about 1970, TRU waste, then classified as low-level waste, was disposed of in shallow trenches without an intent to retrieve it. In 1970, it was

TRANSURANIC WASTE

TRU waste is defined as "waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, per gram of waste, with half-lives greater than 20 years, except for (A) high-level radioactive waste, (B) waste that the Secretary has determined, with concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations; or (C) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with part 61 of title 10, Code of Federal Regulations" (WIPP Land Withdrawal Act, Public Law 102-579).

TRU elements, each having several isotopes, are radioactive and typically man-made. The half-lives of many are considerably longer than 20 years. For instance, the half-life of one isotope of plutonium is 24,000 years.

TRU waste is further classified as contact-handled (CH) TRU waste or remote-handled (RH) TRU waste. CH-TRU waste has radioactivity levels that are low enough to permit workers to directly handle the containers in which the waste is kept. This level of radioactivity is specified as a dose rate of no more than 200 millirems per hour (mrem/hr) at the outside surface of the container. RH-TRU waste has a surface dose rate greater than 200 mrem/hr, so workers use remote manipulators to handle containers of RH-TRU waste. TRU mixed waste is CH-TRU or RH-TRU waste that also contains hazardous materials, such as lead or organic solvents regulated by the Resource Conservation and Recovery Act (RCRA).

[1] Should the Department decide to dispose of TRU waste at WIPP, WIPP could be to begin disposal operations in November 1997, as encouraged in Public Law 104-201; for purposes of analysis in this document, WIPP disposal is assumed to begin in 1998 for the Proposed Action and the action alternatives.

determined that TRU waste should be isolated and disposed of in a different manner than low-level waste. Thus, the Atomic Energy Commission, a DOE predecessor agency, adopted a policy requiring that TRU waste be placed in containers and stored in a manner so as to be retrievable from storage within 20 years. Approximately 62,000 cubic meters (2.2 million cubic feet) of defense CH-TRU waste and 3,600 cubic meters (127,000 cubic feet) of defense RH-TRU waste are in retrievable storage at waste sites around the country.

Additionally, DOE anticipates that approximately 73,000 cubic meters (2.6 million cubic feet) of defense CH-TRU waste and 32,000 cubic meters (1.1 million cubic feet) of defense RH-TRU waste will be generated through the year 2033, from continuing site activities, waste management, and decontamination and decommissioning of DOE facilities.

DOE currently estimates that approximately 138,000 cubic meters (4.9 million cubic feet) of CH-TRU waste and 3,100 cubic meters (108,000 cubic feet) of RH-TRU waste was previously disposed of. Disposal of this buried waste (if excavated) is also considered under the SEIS-II action alternatives. Table 1-1 shows the current and anticipated TRU waste inventory.

Table 1-1
Current and Anticipated DOE TRU Waste (in cubic meters)

Type	CH-TRU Waste	RH-TRU Waste
Stored Through 1995[a]	62,000	3,600
Newly Generated Through 2033[a]	73,000	32,000
PCB-Commingled	720	0
Commercial/Nondefense	200	450
Previously Disposed of Nondefense	138,000	3,100

[a] Defense TRU waste

Continued storage of TRU waste at the generator-storage sites poses potential problems. For example, some of the metal drums used to store TRU waste are showing signs of corrosion, and the contents of these drums eventually will have to be repackaged. Additional storage facilities would be needed at the generator-storage sites. Additional worker exposures to penetrating radiation would occur due to repackaging and inspection of waste containers. New treatment capacity would also be needed because much of the TRU mixed waste (which is about 60 percent of the waste volume discussed above) is subject to RCRA Land Disposal Restrictions (LDR) and cannot be placed in or on the land unless it is treated to satisfy those restrictions. Also, continued storage at certain sites may require modification of legally binding agreements between DOE, the U.S. Environmental Protection Agency (EPA), and/or the states where the waste is located.

In recognition of the potential problems posed by continued storage of TRU waste, the Congress passed The National Security and Military Applications of Nuclear Energy Act of 1980 (Public Law 96-164) authorizing DOE to develop a research and development facility to demonstrate the safe disposal of radioactive waste that has resulted or will result from defense activities and that is exempted from regulation by the U.S. Nuclear Regulatory Commission (NRC) (i.e., TRU waste).

This legislation resulted in the design of a centralized repository for the disposal of TRU waste (after appropriate NEPA review—see below), known as WIPP. The site selected for the repository is located approximately 50 kilometers (30 miles) east of Carlsbad, New Mexico. In 1992,

Congress confirmed the need for the disposal of TRU waste by passage of the WIPP Land Withdrawal Act (LWA) (Public Law 102-579). The LWA reserved the area surrounding the WIPP site for construction, experimentation, operation, repair and maintenance, disposal, shutdown, monitoring, decommissioning, and other activities associated with WIPP. DOE is now proposing to continue the phased development of WIPP by disposing of TRU waste resulting from defense activities and programs.

1.3 WIPP NEPA COMPLIANCE HISTORY

In 1980, DOE prepared the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) to assess the potential environmental impacts of developing WIPP and of alternatives for disposing of or managing defense TRU waste. The FEIS proposed a two-phased approach to the development of WIPP: (1) a site and preliminary design validation program and (2) full construction (DOE 1980).

The alternatives analyzed in the FEIS included the following:

- *Alternative 1:* The No Action Alternative. A research and development facility to demonstrate the safe disposal of TRU waste would not be developed, and post-1970 TRU waste would continue to be retrievably stored.

- *Alternative 2:* The two-phased approach to developing WIPP at its proposed site in southeastern New Mexico.

- *Alternative 3:* Disposing of TRU waste stored at Idaho National Engineering Laboratory in the first available repository for high-level radioactive waste.

- *Alternative 4:* Delaying a decision on the site for WIPP until at least 1984 to allow for the investigation of alternative sites.

In a Record of Decision (ROD) published by DOE on January 28, 1981 (46 Federal Register [FR] 9162), the Department selected Alternative 2, to proceed with the phased development of WIPP at the site in southeastern New Mexico. DOE designed the facility to accommodate 175,600 cubic meters (6.2 million cubic feet) of CH-TRU waste and 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste. The Department concluded in the ROD that the adverse environmental impacts of the phased development of WIPP would be minor and that there would be minimal risk of any release of radioactivity to the environment.

After construction of most of the WIPP facilities, the Department prepared the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990) to update the environmental record established in the FEIS.

SEIS-I evaluated the impacts of the following three alternatives:

- *Proposed Action Alternative:* Continue with a phased approach to develop WIPP, as authorized by Public Law 96-164 and, as modified by changes proposed in SEIS-I, by beginning an underground WIPP Test Phase.

- *No Action Alternative:* No waste would be emplaced at WIPP. Storage of TRU waste would continue at the generator-storage sites, and new storage facilities would be built.

- *Alternative Action:* Only those tests that could be performed without emplacing waste underground would be conducted until it was determined that WIPP complies with EPA standards and other regulatory requirements for the long-term protection of the environment from the disposal of TRU waste.

The SEIS-I ROD, published by DOE on June 22, 1990 (55 FR 25689), chose the Proposed Action Alternative. The 1990 ROD also committed the Department to prepare SEIS-II before the disposal phase and to provide an analysis of the long-term performance of WIPP in light of new information obtained since 1990. The WIPP Test Phase was to have involved the testing of TRU waste underground at WIPP. In October 1993, DOE decided not to conduct the Test Phase. DOE decided that the experiments could be adequately performed at a lower cost in aboveground laboratories as part of the ongoing experimental program.

The 1990 ROD also stated that a more detailed analysis of the impacts of processing and handling TRU waste at the generator-storage facilities would be conducted. The Department has analyzed TRU waste processing and handling throughout its facilities in the *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS) (DOE 1995e). These analyses form the basis of the SEIS-II analyses of generator-storage site impacts. The Draft WM PEIS analyzes environmental impacts at the potential locations of treatment and storage sites (see Figure 1-1) for TRU waste; SEIS-II addresses impacts associated with alternative treatment methods and the disposal of TRU waste at WIPP and alternatives to that disposal.

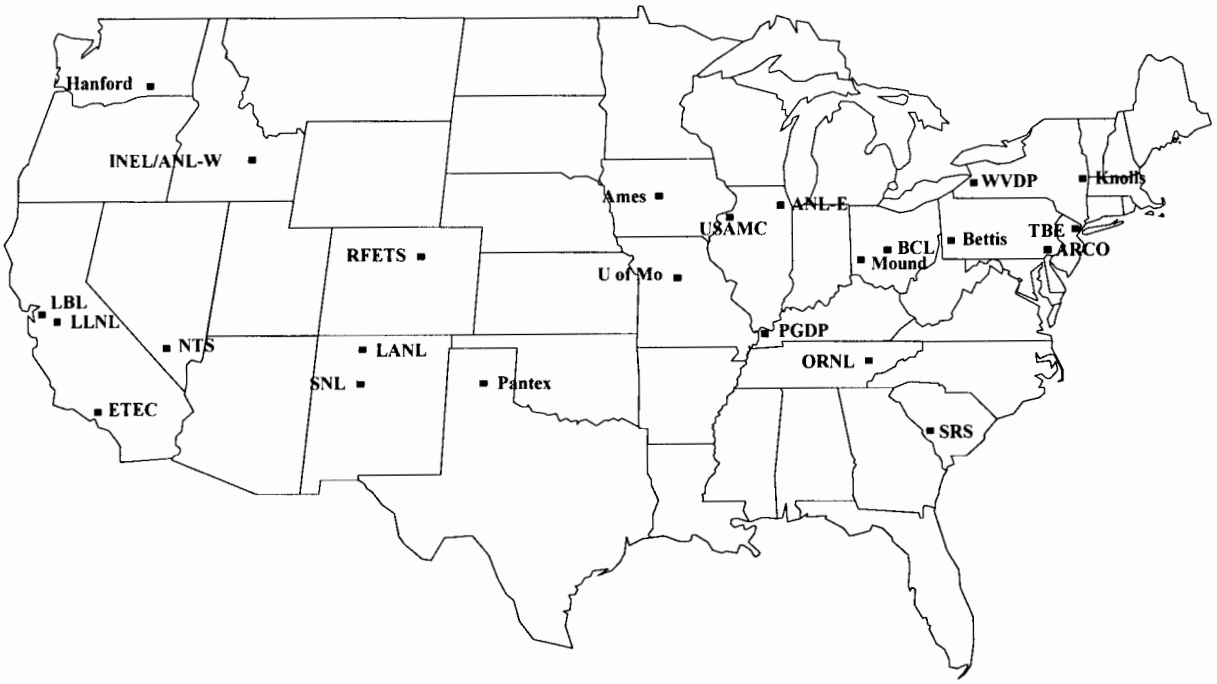


Figure 1-1
Approximate Location of SEIS-II TRU Waste

Since SEIS-I, DOE has published three environmental assessments (EAs) and two supplement analyses related to WIPP. These documents are summarized in Table 1-2. The Department also published a mitigation action plan (MAP) on July 10, 1991 (DOE 1991) for actions to prevent or reduce the environmental impacts associated with DOE's selected alternative. DOE issues an annual report on the progress made in implementing the MAP and the effectiveness of any mitigation and will continue to do so until the mitigation activity is complete. The report is issued annually on the anniversary date of the MAP. DOE has issued the WIPP Annual Mitigation Reports on July 10 of each year since the MAP was published (DOE 1992, 1993, 1994, 1995c, and 1996g).

Table 1-2
WIPP NEPA Documents Since SEIS-I

Document Title	Document Description
Environmental Assessment for the Proposed Actinide Source-Term Test Program at Los Alamos National Laboratory (1995) (DOE/EA-0977)	This EA examined the site-specific environmental impacts of conducting tests at Los Alamos National Laboratory as part of the WIPP experimental program. A finding of no significant impact (FONSI) was issued on January 23, 1995.
Environmental Assessment for the Construction and Operation of the Carlsbad Environmental Monitoring and Research Center (1995) (DOE/EA-1801)	This EA examined the impacts of construction by New Mexico State University and continued Department funding of the operations of the Carlsbad Environmental Monitoring and Research Center. The center independently monitors environmental impacts for ongoing and future WIPP operations as part of its aim to improve environmental monitoring techniques. A FONSI was issued on October 10, 1995.
Environmental Assessment for the Construction and Operation of the Sand Dunes to Ochoa Powerline Project (1995) (DOE/EA-1109)	This EA examined the impacts of constructing a second powerline to supply electricity to WIPP. The Department adopted the Bureau of Land Management's EA and FONSI on May 19, 1995.
Supplement Analysis of Proposed Waste Characterization and Packaging Activities at the Idaho National Engineering Laboratory for the WIPP Test Program (1991) (DOE/EIS-0026-FS/SA1)	This supplement analysis described the environmental impacts of conducting some of the WIPP waste characterization activities at two locations at Idaho National Engineering Laboratory, rather than at one location as described in SEIS-I. The activities analyzed included (1) certification and storage of CH-TRU waste at the existing Radioactive Waste Management Complex, (2) characterization and repackaging of these wastes into bins or 55-gallon drums at the existing Hot Fuel Examination Facility, and (3) transportation of wastes along the 26-mile route between the two facilities. The Department determined that these activities did not involve any substantial changes to the SEIS-I Proposed Action or notable new circumstances or information bearing on the environmental impacts, and no further NEPA documentation was required.
Supplement Analysis of Proposed Transportation Routes to the Waste Isolation Pilot Plant and Discovery of Deviated Gas Well at WIPP (1991) (DOE/EIS-0026-FS/SA2)	This supplement analysis described the selection of TRU waste transportation routes and the discovery of a deviated gas well at WIPP. The analysis also described a directionally drilled or deviated gas well on Section 31 that was drilled in 1982. The Department determined that these activities did not involve substantial changes to the SEIS-I Proposed Action or notable new circumstances or information bearing on the environmental impacts. Therefore, DOE decided that no additional NEPA documentation was required.

1.4 NEED FOR A SECOND SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

In addition to the Department's 1990 ROD commitment to prepare SEIS-II, regulatory and statutory changes and changes in the TRU waste inventory and waste acceptance criteria have occurred. Also, new hydrologic and geologic information is available that may affect the performance assessment of WIPP and its ability to isolate waste. SEIS-II, therefore, takes into account all of the changed circumstances since 1990 that might affect the potential environmental impacts from the WIPP disposal and closure phases. Some of these changes are presented below.

- *Identification of Additional TRU Waste Generator Sites.* SEIS-I identified 10 principal generator-storage sites which have over 99 percent of the TRU waste volume that would be sent to WIPP. In the Draft WM PEIS, the Department identified 10 additional sites that generate and store small amounts of TRU waste that may be disposed of at WIPP. Recent waste volume surveys have identified four other sites that store small quantities of TRU waste that were not identified in the Draft WM PEIS.

- *Changes in TRU Waste Volumes and Waste Forms.* Estimates of the volumes of TRU waste and the final waste forms have changed since 1990. The volume changes are due to the reduction of activities associated with the production of nuclear weapons in the United States and better estimates of waste volumes obtained from the generator-storage sites. The changes in expected final waste forms reflect plans of certain generator-storage sites to treat their TRU waste in a manner that would alter its current form.

- *Changes in Compliance Status of Previously Disposed of TRU Waste.* Until about 1970, DOE disposed of TRU waste in shallow trenches. SEIS-I did not consider this waste in its analyses. Since SEIS-I, it has become evident that compliance with RCRA or the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) may require excavation of a portion of this previously disposed of TRU waste. If excavated, this waste would be considered newly generated. In SEIS-II, an estimate of the previously disposed of inventory is included and analyzed as part of the action alternatives.

- *Passage of the LWA.* The LWA, which transferred the WIPP site from the U.S. Department of the Interior to DOE, included provisions that might affect the environmental impacts of some WIPP disposal alternatives. As an example, one section of the Act allows no more than 175,600 cubic meters (6.2 million cubic feet) of total TRU waste volume and 5.1 million curies of RH-TRU waste to be disposed of at WIPP. Other parts of the Act require studies of rail and truck transportation, RH-TRU waste, and waste processing and volume reduction technologies. This Act was recently modified by Public Law 104-201.

- *Acquisition of New Data from the Experimental Program.* Since 1990, the Department has continued the experimental program and has acquired additional information about the WIPP site, TRU waste, and the potential interactions that may occur between the two. The results of this continuing program include new data that may more clearly define environmental impacts from WIPP. For example, there are reduced uncertainties about the rate and magnitude of gas generation from TRU waste, which bears on the long-term ability of the repository to isolate waste from the environment.

- *Publication of the Draft WM PEIS (August 1995).* The Department is preparing a nationwide study examining the environmental impacts of managing five types of DOE radioactive and hazardous waste, including TRU waste. This study provides information on the potential impacts of various siting alternatives, which DOE will use in deciding where to locate treatment, storage, and/or, depending on the type of waste, disposal facilities. For TRU waste, the Department would identify DOE sites for treatment and storage facilities but not the type of treatment to be performed. The Draft WM PEIS presents new information on TRU waste management. There are some differences in the waste inventories and generator-storage sites discussed in the Draft WM PEIS and in SEIS-II. The differences are due in part to the different time periods analyzed in the Draft WM PEIS and SEIS-II. The differences, and the reasons for them, are explained in Appendix B.

- *Changes to the planning-basis Waste Acceptance Criteria (WAC).* The Department has revised the allowable activity for CH-TRU waste that could be placed in WIPP. The maximum plutonium-239 equivalent activity (PE-Ci) for untreated CH-TRU waste is 80 PE-Ci for a drum and 130 PE-Ci for a standard waste box. If overpacked in standard waste boxes or ten-drum overpacks, untreated CH-TRU waste in 55-gallon drums may contain up to 1,800 PE-Ci of activity.[1] Drums containing solidified or vitrified CH-TRU waste, though, may contain up to 1,800 PE-Ci of activity per drum without overpacking (DOE 1996d).

- *Changes to the Transportation Routes.* Changes have been made to the planned transportation routes presented in SEIS-I.

- *Changes to the TRUPACT-II Certificate of Compliance (NRC 1989).* The NRC has modified the Certificate of Compliance (No. 9218, Revision No. 6). These changes included (1) the addition of tritium-contaminated waste as authorized contents and (2) the revision of generic quality assurance activities. These changes do not affect the ability of the package to meet the requirements of Title 10, Code of Federal Regulations (CFR), Part 71.

- *Changes in the Status of Relevant Regulations.* In 1993, the EPA issued the Environmental Standards for Management and Disposal of TRU Waste codified in 40 CFR Part 191 and in 1996 issued criteria to certify and determine WIPP's compliance with these standards to be codified in 40 CFR Part 194 (61 FR 5224, February 9, 1996). The 40 CFR Part 194 certification criteria are being challenged in court. In 1993, the President issued Executive Order 12856, Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements, to ensure that federal agencies manage their facilities to meet the objectives of the Pollution Prevention Act and to develop goals to reduce releases of toxic chemicals and pollutants to the environment.

1.5 THE RELATIONSHIP OF SEIS-II TO OTHER DOE PLANNING DOCUMENTS

The NEPA process is a part of DOE's planning process. Council on Environmental Quality (CEQ) regulations encourage integrating environmental impact statements "with other planning at the earliest possible time to insure that planning and decisions reflect environmental values"

[1] Overpacking involves placing the 55-gallon drums inside another container and essentially provides double containment of the TRU waste.

(40 CFR Part 1501.2). SEIS-II has been timed to take advantage of information presented in prior documents and to inform current and future planning efforts. The relationship among major planning and compliance documents and SEIS-II is as follows:

- *Compliance Certification Application* (DOE 1996c): This document, prepared in accordance with 40 CFR Part 194 to be submitted in October 1996 is required by the LWA to demonstrate compliance with standards for disposal of TRU waste (40 CFR 191, Subparts B and C). Conceptual models and computer codes being used for performance assessment calculations in the Compliance Certification Application are also being used in SEIS-II to assess the long-term ability of WIPP to isolate radioactive waste from the accessible environment. A draft application was submitted to EPA in July 1995.

- *Resource Conservation and Recovery Act Part B Permit Application* (DOE 1995b): This document is the application to operate WIPP as a disposal facility, as defined under RCRA (40 CFR Part 264). The application provides background information regarding the DOE proposals for operating WIPP and is, therefore, one of the foundations on which assumptions in SEIS-II concerning WIPP operations are based.

- *Final No-Migration Variance Petition (DOE 1996e):* This document, submitted to the EPA and published on June 14, 1996, is a petition to receive a variance from the RCRA LDRs on the basis that the migration of hazardous constituents would not exceed health-based levels at the disposal unit boundary. Such a variance is no longer required pursuant to the National Defense Authorization Act for Fiscal Year 1997. The document also provides background information on the long-term ability of WIPP to isolate hazardous waste and has been summarized and incorporated by reference throughout SEIS-II.

- *Waste Isolation Pilot Plant Safety Analysis Report, Revision 1 (SAR)* (DOE 1995i): The intent of this document, published in November 1995, is to demonstrate the safe disposal of CH-TRU waste in compliance with DOE orders. The SAR provides accident analyses of CH-TRU. Some of these analyses have been incorporated into SEIS-II.

- *Transuranic Waste Baseline Inventory Report, Revision 2 (BIR-2)* (DOE 1995j): This report, published in December 1995, provides the waste volumes, hazardous constituent inventories, and most of the radionuclide data used by DOE in its regulatory compliance applications. It is used as the basis for the SEIS-II waste inventories. SEIS-II supplements the radionuclide inventory with data from the Integrated Data Base (IDB). The supplemented radionuclide data used for SEIS-II analyses incorporates most of the changes in radionuclide inventories that were later adopted in Revision 3 of BIR (see discussion below).

- *Transuranic Waste Baseline Inventory Report, Revision 3 (BIR-3) (published in June 1996):* This report, which DOE used for the WIPP Draft Compliance Certification Application, includes information pertaining to waste that is currently eligible for disposal at WIPP under existing laws. BIR-3 waste volumes and hazardous constituent inventories are unchanged from BIR-2. The radionuclide inventories at some sites are changed. Also, information on complexing agents, nitrates, sulfates, phosphates, and cement was added because these components could potentially affect WIPP's ability to contain TRU waste. The information in BIR-3 was used as the basis for the WIPP Draft Compliance Certification Application. The information on complexing agents, nitrates, sulfates, phosphates, and cement was incorporated into the parameters used in the SEIS-II analysis

of long-term performance. As pointed out above, BIR-2 radionuclide inventories used for SEIS-II analyses were adjusted based on the IDB. The adjusted radionuclide inventories used for SEIS-II analyses are similar to (but not identical to) BIR-3 inventories. DOE evaluated the differences in the two inventories and found that use of BIR-3 inventories instead of the adjusted BIR-2 inventories would lead to equivalent or slightly lower impacts; any differences in impacts would not be discernible after rounding.

- *Comprehensive Disposal Recommendations:* This report (in preparation by DOE, due to be issued in May 1997) will recommend disposal options and timetables for all TRU waste under DOE control, pursuant to requirements of the LWA. The action alternatives in SEIS-II examine the impacts of disposing of the entire DOE TRU waste inventory at WIPP.

- *Remote-Handled Transuranic System Assessment* (DOE 1995h): This report, published in November 1995, discusses the disposal of DOE RH-TRU waste. The report discusses packaging RH-TRU waste at treatment sites in such a way that it could be handled as CH-TRU waste. This would entail placing the RH-TRU waste in shielded payload containers to limit the radiation dose at the outer container surface to not more than 200 mrem/hr. This waste could then be handled and emplaced as CH-TRU waste. All other CH-TRU requirements would apply as well. This study also considered several options for RH-TRU waste emplacement, such as putting the waste in repository walls, in vertical boreholes in the floors of the repository, or in trenches mined in the repository floor. These considerations were used to determine the number of repository panels needed under the Proposed Action and the action alternatives in SEIS-II.

- *Remote-Handled Transuranic Waste Study* (DOE 1995f): This study was conducted, as required by the LWA, to evaluate the impacts of RH-TRU waste on the performance assessment of the repository and to determine the effects of RH-TRU waste as a part of the WIPP Total Inventory. Also, this study conducted a comparison of CH-TRU and RH-TRU waste to assess differences and similarities for gas generation, flammability and explosiveness, solubility, and brine and geotechnical interactions. The conclusions and findings of this study were considered when addressing TRU waste handling and performance assessment concerns in SEIS-II.

- *Decommissioning and Post-Decommissioning Plan:* The LWA requires this plan, which is scheduled for publication in 1997. The plan will discuss the decommissioning of WIPP after its closure and what would then happen to the WIPP facilities and property. Decommissioning and post-decommissioning are addressed in SEIS-II within the discussion of the Proposed Action. Greater detail concerning this phase of WIPP operations will be forthcoming in the *Decommissioning and Post-Decommissioning Plan*.

Based on these documents, DOE believes it has sufficient information to meaningfully evaluate the environmental impacts of the proposal to dispose of TRU waste at WIPP and of the alternatives to that proposal.

In addition, several DOE NEPA documents that are related to SEIS-II either have been completed since SEIS-I, are being prepared, or have been proposed. As discussed below, DOE is preparing project-level, site-wide, and programmatic NEPA documents that address TRU waste management facilities or potential TRU waste generating activities throughout the DOE complex. These parallel efforts are being undertaken to expedite compliance with site-specific consent orders and

settlements and to discharge DOE's responsibilities under NEPA. The decisions that may result from these NEPA reviews may change the amount of TRU waste at DOE facilities. The amount of waste used for SEIS-II quantitative analyses does not reflect these possible decisions. The potential volume changes, though, are expected to be small relative to the total amount of waste considered for the SEIS-II calculations.

Draft Waste Management Programmatic Environmental Impact Statement (Published in 1995, DOE/EIS/0200-D)

The relationship between SEIS-II and the Draft WM PEIS (DOE 1995e) is set forth in Appendix B of this document. SEIS-II uses the Draft WM PEIS to support its analyses in two principal ways. First, it uses the Draft WM PEIS results as a baseline, updates that information, and adjusts the impacts according to differences in the concentration of radionuclides and differences in waste volume from the addition of buried waste, for example under some SEIS-II alternatives. Secondly, SEIS-II transportation analyses use the locations of proposed treatment facilities presented in the Draft WM PEIS (DOE 1995e).

Although SEIS-II incorporates by reference, and where appropriate, updates and adjusts information from the Draft WM PEIS, the potential actions analyzed in SEIS-II are not connected to the potential actions analyzed in the Draft WM PEIS. To further explain, the WM PEIS evaluates alternative configurations for managing five types of waste, including TRU waste, that are at DOE sites or are otherwise under DOE's control or responsibility. The alternative configurations range from managing the wastes where they are presently located to transporting them to one centralized site for management. The WM PEIS evaluates trends in various impacts as alternative configurations become more or less centralized. The WM PEIS postulates three generic types of treatment for TRU waste, in order to analyze the impacts of treating and storing TRU waste under the various alternative configurations. These generic treatments allow DOE, in the WM PEIS, to compare the relative impacts of centralized, regionalized, and decentralized treatment and storage. To reduce the potential impacts of storing untreated wastes, DOE must decide, pursuant to the WM PEIS, the most cost-effective and environmentally preferable configuration to treat and store TRU waste, regardless of whether the Department decides to dispose of this waste at WIPP.

In addition to TRU waste, the WM PEIS analyzes four other types of waste: high level waste, low level waste, low level mixed waste, and hazardous waste. These wastes would not be disposed of at WIPP, and management of these wastes is unrelated to, and outside the scope and purpose of, the SEIS-II.

SEIS-II, in contrast, is the third in a series of staged NEPA reviews and focuses on WIPP disposal of TRU waste. waste. SEIS-II analyzes impacts and alternatives for disposal at WIPP, transportation to WIPP, and associated activities not addressed in, and not within the scope of, the Draft WM PEIS. SEIS-II involves additional and different workers, time frames, transportation modes, alternatives and affected environments. Decisions associated with whether to dispose of TRU waste at WIPP can and should be made regardless of any decisions made pursuant to the WM PEIS. Furthermore, decisions for TRU waste disposal are far removed from decisions on management of the other types of waste analyzed in the WM PEIS. Decisions concerning WIPP pursuant to SEIS-II will not automatically trigger or prejudice decisions for high-level waste, low-level waste, hazardous waste, and low-level mixed waste that may be made pursuant to the

WM PEIS. As such, SEIS-II and the WM PEIS have different purposes, meet different needs, and are independently justified.[1]

Storage and Disposition of Weapons-Usable Fissile Materials Draft Programmatic Environmental Impact Statement (Published in 1996, DOE/EIS-0229-D)

This draft programmatic environmental impact statement (PEIS) (DOE 1996b) analyzes alternatives for the storage and disposition of weapons-usable fissile materials that originate in the United States. Weapons-usable fissile materials are those that could be used to make nuclear weapons and include various isotopes of plutonium (except plutonium-238, which is used as an energy source for space missions) and uranium highly enriched in uranium-235. Specifically, this draft PEIS analyzes alternatives for the storage of surplus weapons-usable plutonium and highly enriched uranium until any disposition, the storage of nonsurplus weapons-usable plutonium and highly enriched uranium, and the disposition of surplus plutonium. Storage alternatives for plutonium and uranium include using current storage facilities (no action alternative), upgrading current facilities, consolidating plutonium storage at a new facility, and collocating plutonium and highly enriched uranium storage at a new facility. Disposition alternatives for plutonium include several alternatives in the following categories: emplacement in a deep borehole; immobilization in glass, ceramic, or metal; and fabrication into mixed oxide fuel with subsequent burning in nuclear reactors. TRU waste may result from actions contemplated by this PEIS; the extent of potential TRU waste generation would depend on the alternative or alternatives selected in the ROD.

Los Alamos National Laboratory Site-Wide Environmental Impact Statement (Draft in Preparation)

DOE is preparing a site-wide environmental impact statement (EIS) for the Los Alamos National Laboratory (DOE 1995g) that will include an analysis of existing and planned waste management activities, including those for TRU waste, for the next 5 to 10 years. The potential environmental consequences that would result from the implementation of existing and anticipated activities, possible mitigation measures, site-specific strategies for TRU waste management, and projects reasonably expected during this period will be addressed.

Draft Environmental Impact Statement for the Nevada Test Site and Off-site Locations in the State of Nevada (Published in 1996, DOE/EIS-0243-D)

A site-wide EIS is being prepared to help define the future mission of the Nevada Test Site (NTS) (DOE 1996a). This site-wide EIS is evaluating resource management alternatives that would support current and future defense related missions, research and development, waste management, environmental restoration, infrastructure maintenance, and facility upgrades and alternative uses over the next 5 to 10 years. Issues being considered that may have a bearing on TRU waste include environmental restoration and other DOE activities at NTS and off-site locations, transportation and disposal of waste generated both on- and off-site, and potential impacts of defense and nondefense programs proposed for NTS.

[1] The analyses presented in the WM PEIS and SEIS-II are more understandable and useful for decision making and for informing the public than they would be if combined in a single, less focused document.

Site-Wide Environmental Impact Statement for the Rocky Flats Environmental Technology Site (Draft in Preparation)

DOE has issued a Notice of Intent (59 FR 4001, August 5, 1994) to prepare a site-wide EIS for the Rocky Flats Environmental Technology Site (RFETS). The Notice described the intended scope of the site-wide EIS as providing a basis for selection of a site-wide strategic approach for nuclear materials storage, waste management, cleanup, and economic conversion, as well as project-level decisions for land use, management of nuclear materials, deactivation of RFETS facilities, decontamination and decommissioning of existing facilities, and possible on-site and off-site transportation of radioactive, hazardous, and mixed waste. The scope of the site-wide EIS has been modified so that issues associated with the safe interim storage of plutonium at RFETS will be analyzed in the Plutonium Interim Storage EIS (Notice of Intent, 61 FR 37247, July 17, 1996), and completion of the site-wide EIS has been deferred pending decisions based on the Final WM PEIS.

Savannah River Site Waste Management Final Environmental Impact Statement (Published in 1995, DOE/EIS-0217)

DOE recently issued the *Savannah River Site Waste Management Final Environmental Impact Statement* (DOE 1995d) that evaluates the construction and operation of low-level mixed waste and TRU mixed waste facilities identified in the Savannah River Site Treatment Plan developed under the Federal Facility Compliance Act (FFCAct) and the effects of minimizing, treating, storing, and disposing of liquid high-level radioactive, low-level radioactive, hazardous, mixed (radioactive and hazardous), and TRU waste. The EIS is intended to support decisions on the operation of specific treatment, storage, and disposal facilities over the next 10 years and to provide a baseline for analyses of future waste management activities. A ROD (60 FR 55249) was issued October 30, 1995, announcing DOE's intention to implement the moderate treatment configuration alternative for storing, and treating transuranic waste, among others. The ROD also indicated that DOE will issue additional RODs pertaining to the treatment of mixed low-level radioactive and TRU mixed waste following negotiations with the State of South Carolina under the FFCAct.

Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement (Published in 1995, DOE/EIS-0203-F)

Relevant to TRU waste management at Idaho National Engineering Laboratory, this site-wide EIS evaluates the potential impacts from the proposed action (1) to develop appropriate facilities and technologies to manage waste, (2) to integrate more fully all environmental restoration and waste management activities, and (3) to manage environmental impacts from these restoration and management activities (DOE 1995a). Based upon this programmatic and site-wide EIS, DOE issued an ROD on June 1, 1995 (60 FR 28680), which when implemented might result in the acceptance of off-site TRU waste from other DOE sites for treatment (pending negotiations under the FFCAct and decisions to be made based on the Draft WM PEIS).

1.6 CONTENT OF SEIS-II

This Draft SEIS-II is composed of six chapters and nine appendices, as follows:

- *Chapter 1, Introduction:* This chapter defines the need for action and describes the underlying purpose. It also presents an overview of the WIPP project, a summary of its

NEPA compliance history, and discussions of other DOE NEPA efforts and planning documents.

- *Chapter 2, Background Information:* This chapter provides an overview of DOE's TRU waste management throughout its facilities, includes details on the WIPP project and facility, presents a discussion of the TRU waste inventories, and summarizes relevant stakeholder outreach and involvement activities.

- *Chapter 3, Description of the Proposed Action and Alternatives:* This chapter is a description of the Proposed Action and each of the alternatives. The Proposed Action is to proceed with the phased development of WIPP by disposing of retrievably stored and future-generated defense TRU waste after treatment to the planning-basis WAC, up to the limits of the LWA and the DOE—New Mexico agreement for consultation and cooperation. There are three alternatives to the Proposed Action, each involving different TRU waste treatment options and different waste volumes. There are two no action alternatives, one in which TRU waste would remain at various DOE sites in compliance with applicable regulations and another in which TRU waste would be stored at consolidation sites. WIPP would not open if either no action alternative is selected.

- *Chapter 4, Description of the Affected Environment:* This chapter summarizes and updates the description of the affected environment of the FEIS and SEIS-I and discusses new information regarding the hydrogeology at the WIPP site. It also summarizes the affected environment at the 10 major generator-storage sites.

- *Chapter 5, Environmental Consequences:* This chapter presents analyses of postulated radionuclide and hazardous chemical releases and exposures, for the Proposed Action and alternatives, the impacts that would result both from routine transportation and operations and from transportation and operational accidents, and the potential impacts of closing WIPP under the no action alternatives and from long-term repository performance after closure under the Proposed Action and the action alternatives. This chapter also includes discussions of environmental justice, the potential impacts of waste retrieval and recovery, cumulative impacts, and mitigation measures. Additional discussions include unavoidable adverse impacts, i.e., those that may remain following mitigation; short-term uses of man's environment and the maintenance and enhancement of long-term productivity; and irreversible or irretrievable commitment of resources that would result from implementation of the Proposed Action.

- *Chapter 6, Consultations and Regulatory Compliance:* This chapter discusses the agencies and persons consulted, and provides the status of compliance with key regulatory requirements.

- *Appendix A, Waste Inventory:* This appendix provides information on the characteristics and quantities of DOE TRU waste.

- *Appendix B, Summary of the Draft Waste Management Programmatic Environmental Impact Statement and Its Use in Determining Human Health Impacts:* This appendix provides an overview of that information in the Draft WM PEIS that is relevant to SEIS-II and how the potential human health impacts of TRU waste management reported in the Draft WM PEIS have been adjusted and updated to account for differences between the Draft WM PEIS and SEIS-II.

- *Appendix C, Air Quality:* This appendix describes the methods used for analyzing potential impacts to air quality at WIPP for routine emissions of nonradiological air pollutants during normal operations.

- *Appendix D, Life-Cycle Costs and Economic Impacts:* This appendix discusses the technical approach and sources of information used to estimate the life-cycle costs and economic impacts of the SEIS-II alternatives.

- *Appendix E, Transportation:* This appendix forms the basis for transportation impact analysis results and discusses plans for transporting TRU waste.

- *Appendix F, Human Health:* This appendix describes the methods used to estimate human health impacts that result from radioactive material and hazardous chemical exposures and intakes.

- *Appendix G, Facility Accidents:* This appendix describes the methods used to estimate the impacts of facility accidents, both at WIPP and at treatment, consolidation, and storage facilities.

- *Appendix H, Long-Term Consequence Analysis for Proposed Action and Action Alternatives:* This appendix describes the analytical methods, codes, and exposure calculations used to determine the impacts from postulated long-term release scenarios.

- *Appendix I, Long-Term Consequence Analysis for No Action Alternative 2:* This appendix describes the analytical methods, codes, and exposure calculations used to determine the impacts from postulated long-term release scenarios.

- *Appendix J, List of Preparers:* This appendix provides the names and credentials of those persons involved in the preparation of SEIS-II.

1.7 REFERENCES CITED IN CHAPTER 1

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CHAPTER 2

CHAPTER 2
BACKGROUND INFORMATION

This chapter provides an overview of the management of transuranic (TRU) waste throughout U.S. Department of Energy (DOE or the Department) facilities, presents details on the Waste Isolation Pilot Plant (WIPP) and its history, and concludes with a summary of stakeholder outreach and involvement activities relevant to the preparation of this supplemental environmental impact statement (SEIS-II).

2.1 OVERVIEW OF TRU WASTE IN THE DOE COMPLEX

During the past 50 years, DOE and its predecessor agencies have been responsible for atomic energy and nuclear weapons research and production. The nuclear weapons complex has consisted of major facilities, including those at large reservations in the states of Nevada, Idaho, Washington, and South Carolina. In New Mexico and California, national laboratories have designed weapons, most of which were assembled in Texas, from components fabricated in Colorado, Florida, Missouri, Ohio, Tennessee, and Washington (DOE 1995c).

TRU waste results from defense activities and programs of the U.S. government. Several types of operations (current, past, or future) have generated or will generate TRU waste: (1) nuclear weapons development and manufacturing; (2) plutonium recovery, stabilization, and management; (3) research and development; (4) environmental restoration, and decontamination and decommissioning; (5) waste management at various DOE and other government facilities and laboratories; and (6) testing at private institutions and universities under contract to DOE. TRU waste also results from commercial activities subject to regulation by the U.S. Nuclear Regulatory Commission (NRC) and from DOE-sponsored activities that are not considered to be defense activities or programs.

KEY DEFINITIONS

Defense TRU Waste: TRU waste that results from defense activities. Since 1970, this waste has been placed in retrievable storage. It continues to be generated from environmental restoration, decontamination and decommissioning activities, waste management programs, and testing and research.

Nondefense TRU Waste: TRU waste that currently is restricted from disposal in WIPP by the WIPP Land Withdrawal Act (LWA) because it does not result from defense activities.

Commercial TRU Waste: TRU waste produced by commercial facilities licensed by the U.S. Nuclear Regulatory Commission (NRC) and restricted from disposal in WIPP because it does not result from defense activities. DOE is managing this waste at the direction of Congress.

Polychlorinated Biphenyl (PCB)-Commingled TRU Waste: TRU waste that contains 50 parts per million or greater of PCBs and is subject to regulation under the Toxic Substances Control Act. This waste is currently restricted from disposal in WIPP unless treated in compliance with the Toxic Substances Control Act or unless WIPP receives a permit to dispose of TRU waste under the Toxic Substances Control Act.

Previously Disposed of Waste: TRU waste that, prior to 1970, was disposed of in shallow burial pits, and that, if excavated, would be considered newly generated waste, potentially eligible for disposal in WIPP.

2.1.1 Introduction

For the purposes of SEIS-II, TRU waste is broadly categorized to include (1) defense waste of the type that was subject to previous WIPP-related National Environmental Policy Act (NEPA) reviews and (2) other defense and nondefense waste for which DOE retains management responsibility. The *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) and *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990) examined the impacts of transporting and disposing of waste that resulted from defense activities and that was placed in retrievable storage pursuant to the Atomic Energy Commission policy of 1970 (see Section 1.2) and TRU waste that was reasonably expected to be generated by these ongoing activities and programs. For the purposes of SEIS-II, this defense TRU waste inventory is hereafter referred to as the "Basic Inventory."

Other defense and nondefense TRU waste not previously included in the waste inventory by the FEIS or SEIS-I include (1) nondefense and commercial TRU waste (comprising 0.2 percent of the total TRU waste volume), (2) defense TRU waste commingled with PCBs, (3) and defense (and perhaps some nondefense) TRU waste disposed of prior to the Atomic Energy Commission policy of 1970. This TRU waste inventory is hereafter referred to as the "Additional Inventory."

In addition, SEIS-II refers to the "Total Inventory," which is the sum of the Basic and Additional Inventories.

WASTE ACCEPTANCE CRITERIA (WAC)

The WAC was first developed in 1989 and revised several times, most recently in 1996. These criteria govern the form, packaging, and transport of TRU waste to be disposed of at WIPP, should WIPP disposal be approved. These criteria also address WIPP operations and safety, transportation requirements, waste package requirements, Resource Conservation and Recovery Act (RCRA) requirements, and performance assessment requirements. Overall, they consolidate the minimum requirements of all laws, regulations, and DOE internal requirements that apply to TRU waste transportation and disposal and establish specific minimum waste characteristics which TRU waste must meet before it can be accepted and emplaced at WIPP.

The WAC establish the conditions that govern the physical, radiological, and chemical composition for TRU waste, setting weight, thermal, and radiological limits. Weight limits are established for TRUPACT-II containers, contact-handled (CH) TRU waste drums, and shipments so that shipments will not exceed highway weight limits. Thermal power limits are established for waste containers to limit the concentration of flammable gas which may be generated within the container. Radiological criteria include the maximum plutonium-239 equivalent activity (PE-Ci) for containers and for stored TRU waste to avoid the potential for nuclear criticality.

For the purposes of SEIS-II analyses, all waste would be treated at a minimum to the current planning-basis WAC. In addition, the alternatives examine more extensive treatment by a shred and grout or thermal process. Even if treated by a shred and grout or thermal process, though, all waste must necessarily also meet the minimum criteria embodied in the WAC to be disposed of at WIPP. Also, to be transported for consolidation or treatment, TRU waste must meet minimum WAC requirements, which include transportation requirements.

The version of the WAC used for the analyses was Revision 5 (DOE 1996c), the most current planning-basis WAC. As laws and regulation change, and should new waste criteria be developed as a result of SEIS-II, the WAC will be revised to reflect the new requirements.

Previously disposed of TRU waste excavated in compliance with RCRA or the Comprehensive Environmental Response, Compensation, and Liability Act would be considered newly generated waste and as such could become potentially eligible for WIPP disposal.

2.1.2 TRU Waste

TRU waste contains TRU and other radionuclides. Most TRU radionuclides decay through the emission of alpha radiation. However, transuranics and other radionuclides present in the waste may emit beta, gamma, X-ray, and neutron radiation as well. Alpha (helium nuclei) and beta (electron) radiation are particulate emissions that cannot penetrate the walls of TRU waste containers and present a health hazard only if the particles are inhaled or ingested. Gamma (photon), X-ray (electromagnetic), and neutron (uncharged particle) radiation can penetrate the walls of waste containers and may present an external dose hazard to individuals near the containers. Gamma and X-ray radiation can be shielded to reduce the radiation dose to workers using high density materials such as lead or steel; neutrons must be shielded using hydrogenous materials such as plastic or paraffin. Radionuclides americium-241, an X-ray emitter, barium-137m, a gamma-emitter that is a decay product of cesium-137, and cobalt-60, another gamma-emitter, are the main contributors to external dose from TRU waste that would be disposed of at WIPP under the Proposed Action and the action alternatives.

TRU waste is categorized as either CH-TRU or remote-handled (RH) TRU based on the external dose rates at the surface of the waste container. TRU waste is considered CH-TRU waste if the external dose rate at the outer surface of the waste container is 200 millirem per hour or less. TRU waste with an external dose rate greater than 200 millirem per hour is considered RH-TRU waste; however, RH-TRU waste with an external dose rate greater than 1,000 rem per hour (1,000,000 millirem per hour) at the outer surface of the container cannot be disposed of at WIPP because it is prohibited by the LWA.

TRU WASTE TRANSPORTATION PACKAGING

The Department plans to use two packagings to transport TRU waste; a third is under consideration.

TRUPACT-II: The TRUPACT-II would be used to transport CH-TRU waste. These containers have been certified by the NRC. To achieve NRC approval, these containers must endure fire, water immersion, and free drops without leakage. Each container has the capacity to hold fourteen 55-gallon drums, two standard (0.9-meter x 1.4-meter x 1.8-meter [3.1-foot x 4.5-foot x 5.9-foot]) waste boxes, or a 10-drum overpack which fits one standard waste box or ten 55-gallon drums. Each TRUPACT-II has a total payload capacity of 2,835 kilograms (6,250 pounds). Up to three TRUPACT-IIs can be transported on a specially designed trailer, and up to six containers can be carried on a specially adapted rail car.

RH-72B: The RH-72B cask would be used to transport RH-TRU waste. The Department is currently awaiting NRC certification of the RH-72B cask. This package is designed to shield personnel and the environment from penetrating radiation that is produced by RH-TRU waste. The canister within each cask can hold up to 3,630 kilograms (8,000 pounds). One RH-72B cask can be carried on a specially designed trailer, and up to three casks can be carried on a specially adapted rail car.

Halfpack: The halfpack is being developed by the Department and is a shorter, lighter version of the TRUPACT-II. It would allow the shipment of waste containers too heavy to be shipped efficiently in a TRUPACT-II because of U.S. Department of Transportation weight limitation requirements. The halfpack would hold half the volume of waste as the TRUPACT-II.

DOE has developed a coding system, comprised of waste matrix code groups, to organize waste streams by their physical and chemical properties. Eleven waste matrix code groups for waste having similar physical and chemical properties have been used to categorize CH-TRU waste and RH-TRU waste (DOE 1995b). These code groups are listed in Table 2-1.

TRU mixed waste is defined as any TRU waste that is commingled with a hazardous waste regulated by RCRA, as defined in Title 40, Code of Federal Regulations (CFR) 261, Subparts C and D. TRU waste containing hazardous chemical constituents has physical and radiological characteristics similar to TRU waste that does not contain these constituents. The majority of TRU mixed waste contains relatively small quantities of spent halogenated solvents, which were used in cleaning and degreasing of equipment, glassware, and components. Based on sampling of gases within TRU waste drums, the most common volatile organic hazardous constituents are methylene chloride, carbon tetrachloride, and 1,1,1-trichloroethane (DOE 1995b). TRU mixed waste also contains various RCRA-regulated metals. These metals are usually associated with solid materials,

Table 2-1
Final TRU Waste Form Definitions

Final TRU Waste Form	Definition
Combustible	Debris that is approximately 95 percent or more, by volume, combustible materials. Examples of combustible debris are materials constructed of plastic, rubber, wood, paper, and cloth.
Filter	Debris that is approximately 50 percent or more, by volume, High Efficiency Particulate Air (HEPA) filters or additional filters constructed of more than one material type (e.g., metal, inorganic nonmetal, and combustibles).
Graphite	Debris that is approximately 95 percent or more, by volume, graphite-based solid materials. Graphite debris includes crucibles, graphite components, and pure graphite.
Heterogeneous	Debris that is at least 50 percent by volume materials that do not meet criteria for assignment into other categories. For example, waste that is a mixture of metal and combustible debris, neither of which comprises 95 percent or more of the waste by volume.
Inorganic nonmetal	Debris that is approximately 95 percent or more, by volume, inorganic nonmetal material. Examples of waste in this group include glass and ceramics.
Lead/cadmium metal	Debris that is approximately 95 percent or more, by volume, metal that contains bulk lead or cadmium as part of the matrix. Examples of this waste include glovebox parts with lead clad in stainless-steel or cadmium sheets.
Uncategorized metal	Debris that is approximately 95 percent or more, by volume, metal but either lacks sufficient information to enable characterization into one of the other categories or contains both lead and cadmium as part of the bulk matrix.
Salt	Debris that is at least 50 percent by volume salts. Stable pyrochemical salt is an example of this group.
Soil	Debris that is approximately 95 percent or more, by volume, soil. This includes sand, silt, and rock/gravel where rock/gravel volumes total less than 50 percent of the matrix.
Solidified inorganic	Debris that is at least 50 percent by volume inorganic process residues. This group includes solidified sludges and small particles.
Solidified organic	Debris that is at least 50 percent by volume organic process residues. These are defined as process residues with a base structure that is primarily organic. The matrix may contain some inorganic solids content such that approximately 20 percent by weight of the waste would remain as residue ash/solids following incineration. Examples include organic resins, organic sludges and solidified organic liquids.

such as lead shielding and chromium-based stainless steel. Lead, chromium, and cadmium are the most prevalent hazardous metals in TRU mixed waste. TRU mixed waste is approximately 60 percent of the Department's TRU waste.[1]

For the TRU waste that would be disposed of at WIPP, DOE has created the planning-basis WAC (DOE 1996b). These criteria specify all of the requirements that must be met by each waste generator-storage site before its TRU waste is shipped to WIPP and disposed of and govern the physical, radiological, and chemical composition of the waste, as well as requirements for waste packaging. Criteria have been developed for shipping, packaging, waste form, waste package, data package, and other miscellaneous criterion categories. These criteria address WIPP operations and safety, transportation, waste package requirements, RCRA requirements, and WIPP performance assessment requirements.

For example, some of the criteria under the waste package requirements include the following:

- The maximum gross weight of the TRUPACT-II with payload is 8,730 kilograms (19,250 pounds) and the maximum gross weight of the canister of the RH-72B cask is 3,630 kilograms (8,000 pounds).

- Total gross weight of a transporter including payload is 36,300 kilograms (80,000 pounds).

- The maximum plutonium-239 equivalent activity (expressed as PE-Ci) for untreated TRU waste is 80 PE-Ci for a drum or 130 PE-Ci for a standard waste box. If overpacked in standard waste boxes or 10-drum overpacks, untreated CH-TRU waste in 55-gallon drums may contain up to 1,800 PE-Ci of activity. Drums containing solidified or vitrified CH-TRU waste may contain up to 1,800 PE-Ci of activity per drum. RH-TRU waste canisters may not exceed 1,000 PE-Ci (DOE 1996b).

- Liquid waste cannot exceed 2 liters (0.5 gallons) in a CH-TRU waste drum, 8 liters (2 gallons) in a standard waste box, or 6 liters (1.5 gallons) in a RH-TRU waste canister.

- The maximum removable surface contamination on drums is 50 picocuries (pCi) per 100 square centimeters (16 square inches) for alpha-emitting radionuclides and 450 pCi per square centimeters (16 square inches) for beta and gamma-emitting radionuclides.

- The maximum thermal power must be less than 40 watts for a TRUPACT-II and be less than 300 watts for a RH-TRU waste canister.

Future additions or revisions to the planning-basis WAC may be necessary; for example, additional RCRA requirements may be issued or results of the WIPP performance assessment studies may require changes. Any changes to the planning-basis WAC based on SEIS-II analyses will be identified in the Record of Decision (ROD). Section 2.2.1 and Appendix A discuss planning-basis WAC further.

[1] The *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS) states that 55 percent of the Department's TRU waste inventory is TRU mixed waste. SEIS-II, though, considers a more recent estimate of the inventory.

2.1.3 Waste Management at the Generator-Storage Sites

The locations and volumes of the TRU waste inventory are given in Table 2-2 (for the Basic Inventory) and Table 2-3 (for the Additional Inventory).

The 1990 SEIS-I (DOE 1990) stated that WIPP may eventually dispose of post-1970 defense TRU waste from 10 sites. These sites are identified in Table 2-2. Since 1990, DOE has identified 14 additional sites that either store or are anticipated to generate TRU waste. Ten of these sites store or generate TRU waste considered to be part of the Basic Inventory (Table 2-2). TRU waste

Table 2-2
Basic Inventory TRU Waste Volumes [a]

	Stored (1995) (cubic meters)		Estimated Total through 2022 [b] (cubic meters)		Projected Total through 2033 [c] (cubic meters)	
Site [d]	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	12,000	200	46,000	22,000	57,000	29,000
Los Alamos National Laboratory (LANL)	11,000	94	18,000	190	21,000	230
Idaho National Engineering Laboratory (INEL)	28,000	220	28,000	220	28,000	220
Argonne National Laboratory - West (ANL-W)	7	19	750	1,300	1,000	1,700
Argonne National Laboratory - East (ANL-E)	25	---[e]	150	---	200	---
Savannah River Site (SRS)	2,900	---	9,600	---	12,000	---
Rocky Flats Environmental Technology Site (RFETS)	4,900	---	9,300	---	11,000	---
Oak Ridge National Laboratory (ORNL)	1,300	2,500	1,600	2,900	1,700	3,100
Lawrence Livermore National Laboratory (LLNL)	230	---	940	---	1,200	---
Nevada Test Site (NTS)	620	---	630	---	630	---
Mound Plant (Mound)	300	---	300	---	300	---
Bettis Atomic Power Laboratory (Bettis)	---	---	120	7	170	9
Sandia National Laboratories - Albuquerque (SNL)	7	---	14	---	17	---
Paducah Gaseous Diffusion Plant (PGDP)	---	---	6	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	3	---
Energy Technology Engineering Center (ETEC)	2	6	2	7	2	7
University of Missouri Research Reactor (U of Mo)	1	---	1	---	1	---
Pantex Plant (Pantex)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	---	---	1	---	1	---
Teledyne Brown Engineering (TBE)	1	---	1	---	1	---
Battelle Columbus Laboratories (BCL)	---	580	---	580	---	580
Totals	**62,000**	**3,600**	**116,000**	**27,000**	**135,000**	**35,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995f), which takes into account potential thermal treatment at some sites. The thermal treatment, though, is not necessarily for PCB-commingled waste. The Basic Inventory is waste that resulted from defense activities and that was placed in retrievable storage pursuant to the Atomic Energy Commission policy of 1970 and TRU waste reasonably expected to be generated by these ongoing activities. Volumes have been rounded. Actual totals may differ due to rounding. Projected totals have not been adjusted in anticipation of disposal.
[b] Post-1970 defense TRU waste volumes through 2022 are estimated in BIR-2 (DOE 1995f).
[c] The Proposed Action, described in Chapter 3, is based on operation of WIPP for 35 years through 2033. Total includes TRU waste to be generated for 35 years.
[d] Sites in boldface were included in SEIS-I. INEL and ANL-W are located near each other and are counted as a single site in SEIS-II; however, ANL-W is listed separately to indicate its contribution to the inventory.
[e] Dashes indicate no waste.

Table 2-3
Additional Inventory TRU Waste Volumes[a, b, c]

Site[d]	PCB-Commingled (cubic meters)		Commercial/Nondefense (cubic meters)		Previously Disposed of (cubic meters)		Total (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	240	---[e]	---	---	63,000	1,000	63,000	1,000
Los Alamos National Laboratory (LANL)	---	---	---	---	14,000	120	14,000	120
Idaho National Engineering Laboratory (INEL)	460	---	---	---	57,000	440	57,000	440
Savannah River Site (SRS)	---	---	---	---	4,900	---	4,900	---
Oak Ridge National Laboratory (ORNL)	---	---	5	---	61	120	66	120
Mound Plant (Mound)	19	---	---	---	---	---	19	---
Sandia National Laboratories - Albuquerque (SNL)	---	---	---	---	1	---	1	---
ARCO Medical Products Company (ARCO)	---	---	1	---	---	---	1	---
Knolls Atomic Power Laboratory (Knolls)	---	---	---	81	---	---	---	81
Lawrence Berkeley Laboratory (LBL)	---	---	2	---	---	---	2	---
West Valley Demonstration Project (WVDP)	---	---	190	370	---	1,400	190	1,700
Totals	**720**	**---**	**200**	**450**	**138,000**	**3,100**	**139,000**	**3,500**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995f), which takes into account potential thermal treatment at some sites. The thermal treatment, though, is not necessarily for PCB-commingled waste. The Additional Inventory includes PCB-commingled TRU waste, commercial TRU waste, nondefense TRU waste, and TRU waste disposed of prior to the Atomic Energy Commission policy of 1970.

[b] The volume of TRU waste includes the 1995 existing and projected waste through 2033 (DOE 1995f).

[c] Actual totals may differ due to rounding.

[d] Sites in boldface also store post-1970 defense TRU waste, see Table 2-2. The remaining four sites currently have no post-1970 defense TRU waste.

[e] Dashes indicate no waste.

stored at the remaining four sites (ARCO Medical Products Company, Knolls Atomic Power Laboratory, Lawrence Berkeley Laboratory, and West Valley Demonstration Project) is part of the Additional Inventory (Table 2-3). Together, TRU waste at these 24 sites account for all waste analyzed as part of SEIS-II (see Figure 2-1).

Additional information about the TRU waste inventory may be found in Appendix A. The waste volumes shown in Tables 2-2 and 2-3 are based on 35 years of future projected generation beginning in 1998, plus the TRU waste in retrievable storage. Projections between 1995 and 1998 are included. DOE recognizes that TRU waste may continue to be generated after 2033 but believes that volume projections beyond 2033 are too speculative to be useful for the analyses at this time; however, DOE may include projections beyond 2033 in any future NEPA analyses.[1]

There is uncertainty in the total waste volume figures presented in Tables 2-2 and 2-3. The projections beyond 2022 are extrapolations based on the projected waste generation rates between 1995 and 2022 and provide bounding estimates for use in the analyses. The amount of previously disposed of TRU waste that could be retrieved for eventual storage or disposal is highly uncertain. Decisions on disposition of waste and contaminated media from environmental restoration activities are made on a cleanup-by-cleanup basis, and such decisions have not been made for many of the Department's environmental restoration activities. Also, the Department is in the process of characterizing and developing cleanup strategies for many contaminated sites and, therefore, cannot precisely determine what type or volume of waste might result from cleanup of those sites.

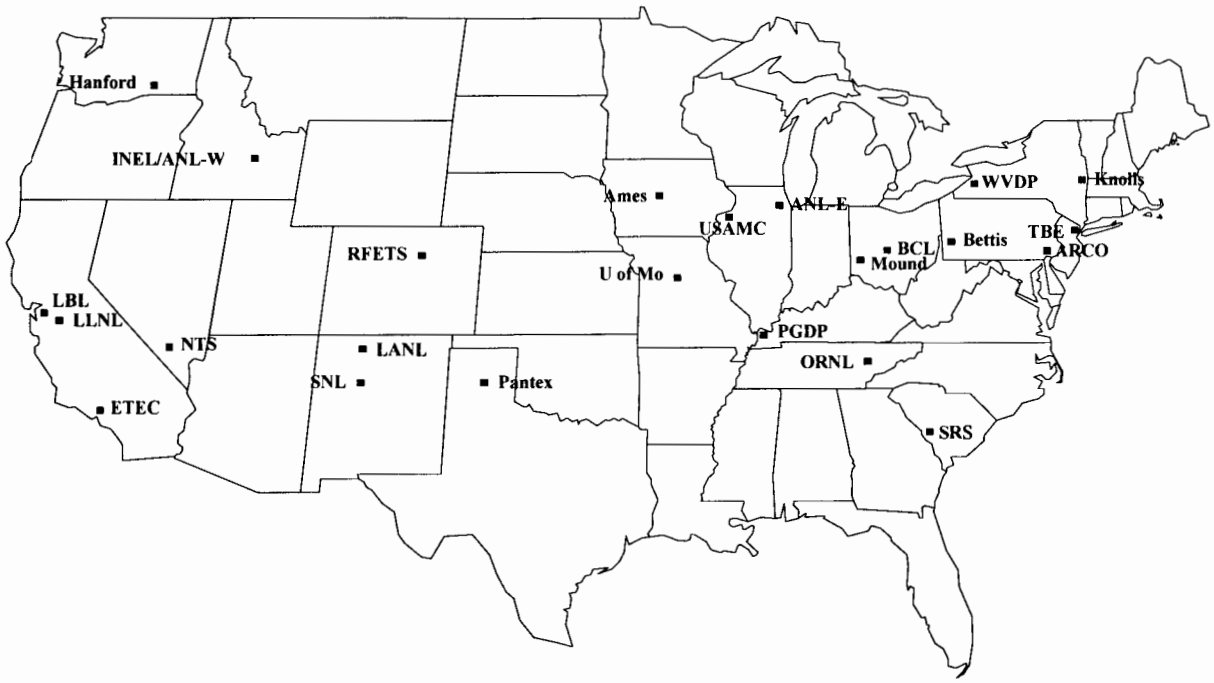


Figure 2-1
Approximate Location of SEIS-II TRU Waste

[1] While SEIS-II provides an analysis of impacts based on 35 years of waste generation, the Department's current RCRA Part B Permit Application (DOE 1996a) is based on 25 years and will be renewed every 5 years.

In addition, the waste volumes used for SEIS-II analyses are estimates of "emplaced waste volumes" (the volumes of the containers that TRU wastes would be emplaced in), not actual waste volumes inside the containers, except as noted. DOE recognizes that virtually all containers would contain some void space and that some containers may be only partially filled (for instance, to meet limits on weight or thermal power for transportation).

The ROD (55 Federal Register [FR] 25689) based on SEIS-I (DOE 1990) stated that SEIS-II would examine in greater detail waste management at the generator-storage sites. Later in 1990, DOE announced its intent to prepare a programmatic environmental impact statement for managing the treatment, storage, and disposal of radioactive and hazardous waste in the DOE Complex, including the treatment and storage of TRU waste (55 FR 42633). Also, in 1992, the U.S. Congress passed the Federal Facility Compliance Act (FFCAct) requiring DOE to prepare plans for developing treatment capacities and technologies for mixed waste. The FFCAct requires the site treatment plans to be submitted to the states or the U.S. Environmental Protection Agency (EPA) for review, and authorizes the states or EPA to issue orders requiring compliance with the plans. The *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS), published in August 1995 (DOE 1995c), was developed in parallel with the FFCAct site treatment plans.

To date, DOE has submitted FFCAct site treatment plans for a majority of its sites, and in most cases orders or settlements have been reached with the states and the EPA. Certain of these orders and settlements also include schedules for transporting treated TRU waste to WIPP. The site treatment plans reflect DOE's strategy for the management of TRU mixed waste. Most of the FFCAct agreements allow the Department to continue to store TRU mixed waste without treating it to meet the RCRA Land Disposal Restrictions (LDR), recognizing that DOE has plans to decide whether to dispose of this waste at WIPP. (Such TRU mixed waste could be disposed of at WIPP without treatment to meet the RCRA LDRs under the recent amendments to the LWA in Public Law 104-201.) The Los Alamos National Laboratory (LANL) FFCAct agreement is an exception to this general rule, requiring DOE to begin planning for the LDR treatment of LANL TRU mixed waste but allowing renegotiation should WIPP open. DOE has reached a negotiated settlement with the State of Idaho under which DOE is to procure, construct, and operate a mixed waste treatment facility; DOE currently plans to use a mixed waste thermal treatment process that would meet the LDRs. Treatment of all the TRU waste to meet the LDRs is still a reasonable alternative and is analyzed in SEIS-II.

Under any of the alternatives assessed in SEIS-II, the generator-storage sites would maintain the capability to manage TRU waste generated in the future. In general, the facilities would vary by site depending on the waste streams and volumes generated and could have the capability to do the following:

- Safely store TRU waste generated from the various waste streams
- Characterize TRU waste which could involve radioassay and nondestructive testing, headspace sampling, inner-bag gas sampling, drum venting, solids sampling, real-time radiography, and visual sampling
- Treat TRU waste through size reduction, vitrification, or thermal treatment
- Certify TRU waste to meet planning-basis WAC requirements

- Package TRU waste
- Load TRU waste containers

These facilities would provide the generator-storage sites with the capability to prepare TRU waste for shipment to the major treatment sites. Treatment sites would have capabilities similar to those listed above for the generator-storage sites but would generally be sized to handle a greater volume of TRU waste.

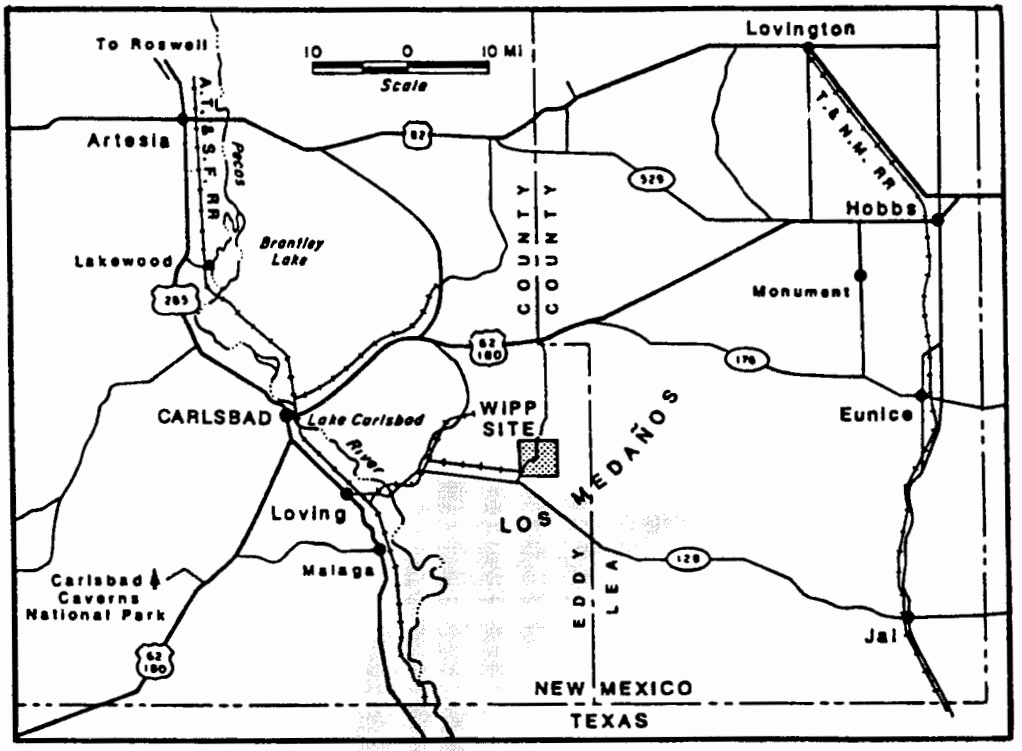
Additional information regarding alternatives for the management of TRU waste in the DOE Complex being studied in the Draft WM PEIS may be found in Appendix B.

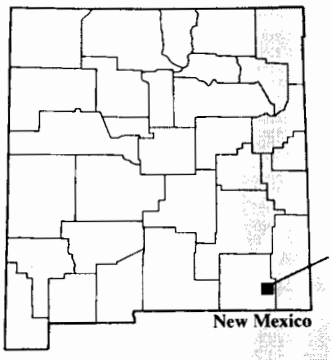
2.1.4 Waste Isolation Pilot Plant

The WIPP site is located in southeastern New Mexico (Figure 2-2). The site is approximately 50 kilometers (30 miles) east of Carlsbad, New Mexico, in an area known as Los Medaños, a relatively flat, sparsely inhabited plateau with little surface water (DOE 1990). WIPP consists of the 41-square-kilometer (16-square-mile) area under the jurisdiction of DOE pursuant to LWA. The WIPP site boundary was established to ensure that at least 1.6 kilometers (1 mile) of intact salt exists laterally between the waste disposal area and the accessible environment and to ensure that no permanent residences will be established in close proximity to the facility.

WIPP includes surface and underground facilities that would support waste handling and emplacement. These facilities were discussed in Section 2.2 of SEIS-I (DOE 1990). The principal surface structure at WIPP is the Waste Handling Building (Figure 2-3). The primary function of the Waste Handling Building and its associated systems is to unload TRU waste (from the TRUPACT-II for CH-TRU waste and from the RH-72B cask, if it is NRC certified for RH-TRU waste) and to transfer the containers of TRU waste to the underground disposal area through a waste shaft. The Waste Handling Building contains four functional areas: the CH-TRU waste handling area, the RH-TRU waste handling area, the waste handling building support area, and the waste shaft (DOE 1995b). Other surface facilities include the hoist houses, support building, guard and security building, water pump house, TRUPACT-II maintenance building, training building, office trailers, exhaust filter building, warehouse and shops, engineering building, drill core storage building, and the safety and emergency services building.

The WIPP underground facilities are located at the repository horizon 655 meters (2,150 feet) beneath the surface (Figure 2-4). These facilities include the waste disposal area, an experimental region (deactivated in 1995 and 1996), access tunnels, and associated support facilities (DOE 1995b). The underground support facilities include those needed to service and maintain equipment for excavation and disposal operations, monitor for contamination, and allow limited decontamination of personnel and equipment, if necessary. All WIPP facilities currently have protection for potential fire, tornado, lightning, high wind, and other types of natural disasters. All underground facilities also are inspected by both the Occupational Safety and Health Administration and the Mine Safety and Health Administration.





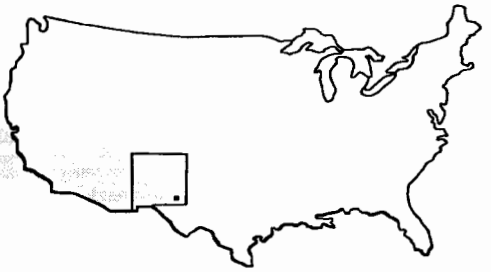
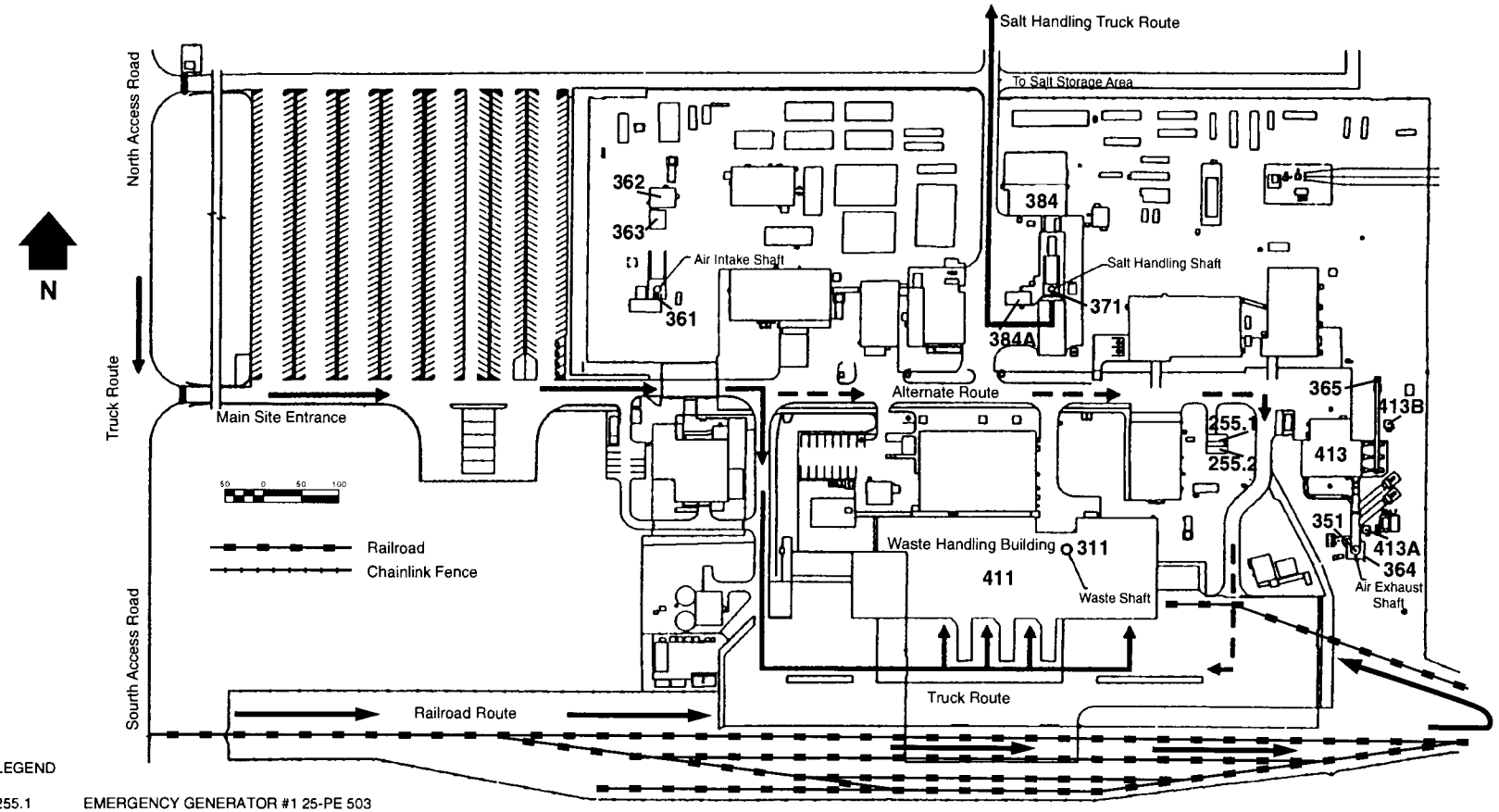


Figure 2-2
The Location of WIPP



LEGEND

255.1	EMERGENCY GENERATOR #1 25-PE 503
255.2	EMERGENCY GENERATOR #2 25-PE 504
311	WASTE SHAFT
351	EXHAUST SHAFT
361	AIR INTAKE SHAFT
362	AIR INTAKE SHAFT/HOIST HOUSE
363	AIR INTAKE SHAFT/WINCH HOUSE
364	EFFLUENT MONITORING INSTRUMENT SHED A
365	EFFLUENT MONITORING INSTRUMENT SHED B
371	SALT HANDLING SHAFT
384	SALT HANDLING SHAFT HOISTHOUSE
384A	SALT HOIST OPERATIONS
411	WASTE HANDLING BUILDING
413	EXHAUST-SHAFT FILTER BUILDING
413A	MONITORING STATION A
413B	MONITORING STATION B

Figure 2-3
WIPP Surface Structures

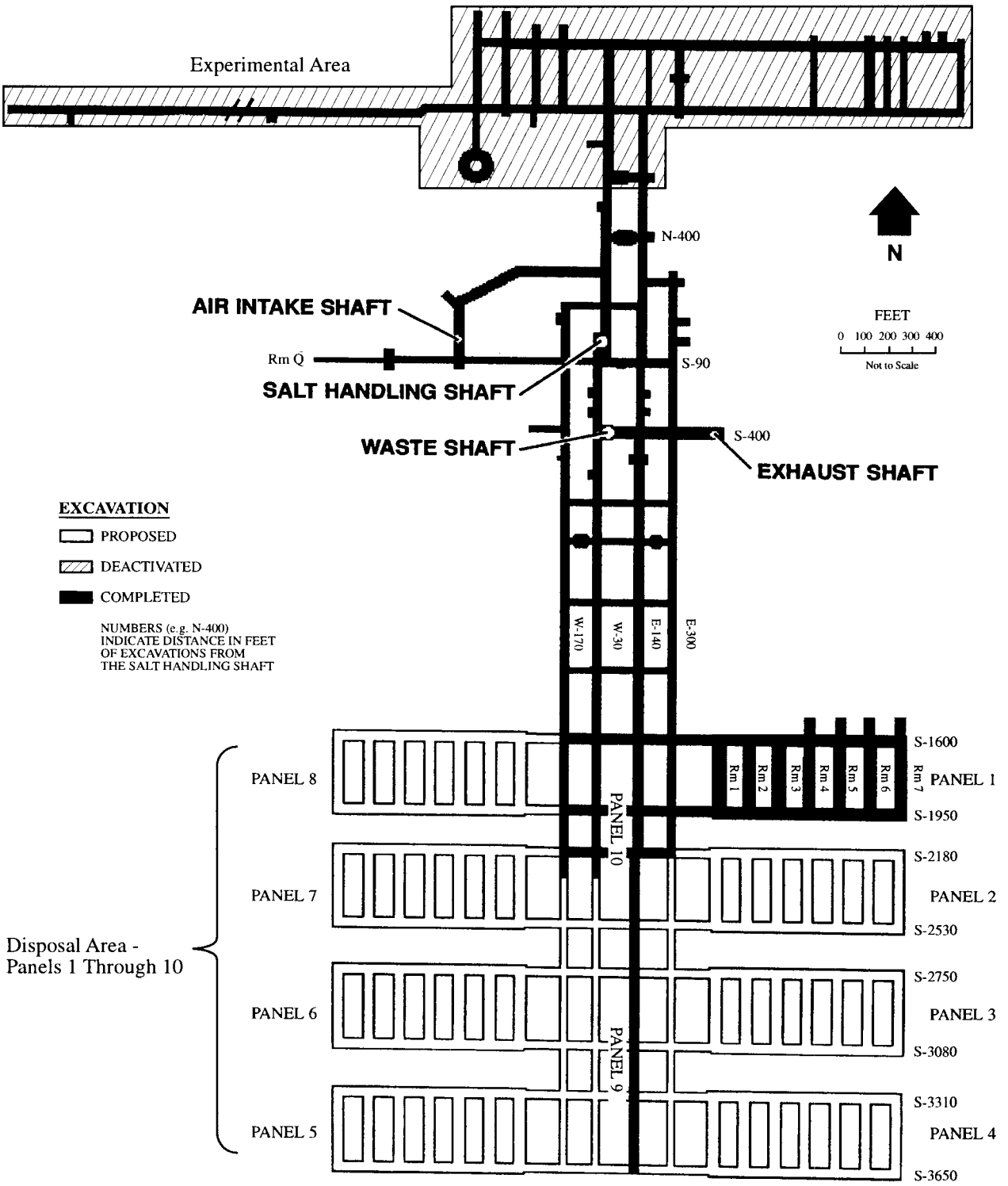


Figure 2-4
Plan View of WIPP Underground Facility
(655 meters [2,150 feet] below ground level)

One underground panel has been excavated. Seven additional panels and the north-south accessways (i.e., panel-equivalents 9 and 10) would be necessary to accommodate the 175,600 cubic meters (6.2 million cubic feet) of TRU waste permissible under LWA. Each panel would consist of seven waste disposal rooms, each about 91 meters (300 feet) long, 10 meters (33 feet) wide, and 4 meters (13 feet) high. Pillars between rooms would be 30 meters (100 feet) wide. Rockbolts or other types of ground control techniques would be used, as necessary, to ensure safe conditions during waste emplacement activities (DOE 1995b).

2.2 TRU WASTE TREATMENT

Although there are many different physical, chemical, and thermal treatments previously tested or in development for TRU waste treatment (DOE 1995e), the three types of treatment in SEIS-II are those assessed in the Draft WM PEIS (DOE 1995c). To ensure that the full range of potential impacts are considered, the Draft WM PEIS considered three types of treatment based on increasing levels of complexity: a minimal level of treatment needed to meet planning-basis WAC, an intermediate level of treatment using a shred and grout process, and a more complex level of treatment sufficient to comply with the LDRs of RCRA. Such treatments are analyzed more extensively in SEIS-II.

The Proposed Action and one alternative would treat and package TRU waste only as needed to meet planning-basis WAC. A second alternative would use a shred and grout process, increasing the volume of the TRU waste by encapsulating it in cement. One alternative and one no action alternative would use a thermal treatment process to destroy organic components of the TRU waste and fuse the remainder into a glass or ceramic product, or possibly, into a metal ingot. Both CH-TRU and RH-TRU waste would be treated by the same processes; only the handling of the TRU waste would vary.

These three levels reasonably bound the potential environmental impacts for other types of treatment that might be developed for future TRU waste application. DOE will select the type of treatment necessary to satisfy disposal and storage criteria. The decisions that DOE makes on the basis of SEIS-II may be a combination of the treatment methods analyzed. This means that two or more of the treatment options may be selected for different portions of the waste.

OBJECTIVES OF TRU WASTE TREATMENT

TRU waste needs to be treated in order to put it in a form that would allow it to be safely handled, transported, and disposed of.

Treatment requirements are established to ensure compliance with requirements established by law, regulations, and DOE internal orders that are designed to protect the safety and health of workers. For example, planning-basis WAC prohibit waste containing over 50 parts per million of PCBs because land disposal of that waste would require a permit under the Toxic Substances Control Act (TSCA), which WIPP currently does not plan to obtain. Other planning-basis WAC limitations, such as limitations on free liquids, are imposed because of the potential impacts of certain waste forms on the ability of WIPP to isolate the radioactive portion of the waste as required by EPA regulations (40 CFR Part 191).

Several RCRA requirements, including the prohibitions on explosives, compressed gases, and corrosive materials, are incorporated into the planning-basis WAC.

2.2.1 Treatment to Meet Planning-Basis WAC

Planning-basis WAC (DOE 1996b) defines the physical, quality assurance, handling, and documentation requirements that must be met for a container of TRU waste to be accepted at WIPP for disposal. The requirements specify TRU waste characteristics and limits and include radionuclide content, activity levels, and permissible shipping container weight. Explosives, compressed gases, and corrosive materials are prohibited by planning-basis WAC. Restrictions are set on amounts of residual liquids, thermal power, and pyrophoric materials. Planning-basis WAC includes WIPP-specific requirements as well as requirements set by various regulatory agencies, including the NRC, EPA, and U.S. Department of Transportation. Stored TRU waste may be WAC-certified or may need treatment to meet planning-basis WAC certification requirements.

Chapter 5 of this document explains how impacts would differ among alternatives if portions of the total waste volume analyzed were treated under each treatment option should the Department decide to combine two or more treatment options.

The baseline process used by treatment sites to ensure that TRU waste meets planning-basis WAC includes:

- TRU waste retrieval from storage
- TRU waste characterization in accordance with the *Transuranic Waste Characterization Quality Assurance Program Plan* (DOE 1995g)
- TRU waste treatment and packaging as needed to allow shipment in the TRUPACT-II or RH-72B packaging. Waste treatment might involve removing or solidifying residual liquids or packaging existing TRU waste so that the waste would fit into appropriate shipping containers.
- TRU waste certification to planning-basis WAC

TRU waste characterization is an important step in determining whether the final TRU waste form meets planning-basis WAC. Depending on the TRU waste matrix code groups, characterization would include some or all of the following:

- Nondestructive, nonintrusive assay to identify and quantify the radionuclides in the TRU waste
- Radiographic analyses to determine the physical form of TRU waste in closed containers
- Container headspace gas analysis to detect the presence of hydrogen, methane, or EPA-listed volatile organic compounds
- Solids analyses for the presence of hazardous metals such as lead, cadmium, or beryllium
- Visual inspection of an appropriate number of containers to verify quality control

Treatment sites would properly treat TRU waste identified as nonconforming during characterization. Treatment facilities would be designed to protect workers, the public, and the environment from exposure to radioactive and hazardous materials.

Planning-basis WAC uses thermal power limits as a surrogate for the gas generation potential of TRU waste. When TRU waste is in close proximity to organic materials, hydrogen gas can be produced, and hydrogen gas can be an explosion hazard. Thermal power limits vary according to the radiation and the packaging of the TRU waste within a container. For example, the hydrogen concentration for waste transported in a TRUPACT-II is limited to no greater than 5 percent (within the innermost layer of packaging) over a 60-day period. Because packaging CH-TRU waste in plastic bags inhibits the dispersal of the generated gas, the rate of gas dispersion decreases with increasing bag layers. Therefore, the more bag layers present in CH-TRU waste packaging, the greater the amount of gas present, the lower the allowed thermal power (DOE 1994) and thus, a smaller volume of CH-TRU waste would be allowed per waste container to limit gas generation. For the purposes of analyses in SEIS-II, it was assumed that no bags were used (bagless posting), thereby maximizing the volume of waste in a container and the concentration of waste that would be emplaced at WIPP. This assumption also would reduce the number of waste shipments.

2.2.2 Shred and Grout Treatment

In a shred and grout treatment process, TRU waste would be shredded to achieve a relatively uniform size and then mixed with grout. Small particles and free liquids would be immobilized with this process and any pyrophoric or corrosive characteristics of the TRU waste would be eliminated. Shred and grout treatment may also reduce the gas generation potential of TRU waste forms that already meet WAC. The gas generation potential in this case refers to the production of methane and other gases by rusting metals and decomposing materials.

An optimum shred and grout process for TRU waste treatment has not yet been selected by DOE. Site-specific NEPA review would be prepared by the Department if this type of treatment were selected for use at the treatment sites. The process selected may be modeled after commercially available technology.

Shredding TRU waste would be accomplished through a mechanical device that cuts, tears, or breaks the TRU waste into small uniform pieces. Most commercially available shredders feed the material between counter-rotating drums with intermeshing knives or teeth. Rocky Flats Environmental Technology Site purchased a shredder that is designed to reduce graphite molds, HEPA filters, and process filters to pieces no larger than 2.5 x 5 x 5 centimeters (1 x 2 x 2 inches). The WIPP *Engineered Alternatives Cost/Benefit Study Final Report* (DOE 1995d) describes a shredding process that would result in pieces with a maximum dimension of 10 centimeters (4 inches).

Both organic and inorganic solid TRU waste would be suitable for treatment by shred and grout. Shredding generally reduces the TRU waste volume by allowing more efficient packing of smaller pieces; however, adding grout tends to increase the overall volume by about 20 percent.

Portland cement, sand, and fresh water are typically used to make grout. An alternate formulation has a cement base, salt for aggregate rather than sand, and simulated WIPP brine in place of fresh water. Additives would be used to control the long-term behavior of the grout. In addition, the formulation and application of the grout could be optimized for various TRU waste streams. For example, one process would combine the TRU waste and the grout before placing the mix in drums; another would add TRU waste and grout in alternating layers and then vibrate the drums; a third process would add grout to drums filled with TRU waste and then vibrate the drums.

TRU waste treatment facilities would check waste drums for radioactive contamination, decontaminate as necessary, then weigh, label, and temporarily seal the drums. After letting the grout mixture cure for several days, waste drums would undergo an inspection, and permanent lids would be installed. Finally, waste drums would undergo inspection to certify that they meet planning-basis WAC.

Much of the shred and grout treatment would be conducted using remote handling techniques, even for CH-TRU waste, because of the potential for airborne contaminant release during the shredding process. Facilities and processes would be designed to protect workers, the public, and the environment from exposure to radioactive and hazardous materials.

2.2.3 Thermal Treatment

Thermal treatment of TRU mixed waste would be designed to meet the LDRs as well as similar requirements of the TSCA. Such treatment would destroy or immobilize the hazardous substances that RCRA and TSCA regulate. (Although thermal treatment to meet RCRA LDRs would otherwise be necessary for about 60 percent of the TRU waste that DOE owns or is responsible for, the recent amendments to the LWA in Public Law 104-201 exempts WIPP disposal from such RCRA requirements.) DOE is currently pursuing plans to use a thermal treatment process at Idaho National Engineering Laboratory to treat both TRU mixed waste and TRU waste commingled with PCBs. Existing or future NEPA documentation has or would be prepared by the Department for these treatment facilities.

Thermal treatment involves exposing TRU waste to temperatures in excess of 3,000 degrees Celsius (°C) (5,400 degrees Fahrenheit [°F]). Nearly all TRU mixed waste streams in the DOE complex could be treated thermally, including solid combustibles and heterogeneous debris. The high temperatures would destroy organic materials and convert inorganic components to either a glassy slag, a metal phase, or a consolidated waste form. These phases could be separated out and offer the potential for recycling.

Most of the alpha-emitting radionuclides and heavy metals would be bound as oxides in the slag, which would be expected to pass the EPA toxicity characteristics leach procedure. Such a high temperature treatment processes might also include a secondary, fuel-fired combustion chamber for treating off-gases to ensure a high efficiency in destroying all organic materials, regardless of the initial properties of the TRU waste.

The thermal process would produce aqueous liquids that would need to be neutralized and wet solids, debris and residues that would need to be disposed of as low level waste (DOE 1995c). DOE would consider the impacts of these waste streams in future NEPA studies when selecting a specific treatment process and a specific site for a treatment facility.

Potential thermal treatment processes are discussed in a 1995 DOE publication entitled *Alternatives to Incineration Technical Area Status Report* (DOE 1995a). Summaries of three of these processes follow:

Plasma Torch and Electric Arc Technologies

Both the plasma torch and electric arc technologies involve a high-voltage discharge in a gas to form a plasma. They differ in that the plasma torch process involves plasma discharge in a flowing gas that stabilizes the arc and provides the thermal source. In contrast, the electric arc process

involves plasma discharge in a nonflowing gas medium that provides the primary energy for heating and melting the TRU waste. The two plasma technologies can accept a variety of TRU wastes and TRU waste matrices. Depending on the system design, TRU waste liquids, soils and sludges, and even entire containers may be melted to form a molten slag.

A reducing environment is typically used to thermally treat volatile organic constituents. Process byproducts are synthetic off-gases and organics, which are combusted in an afterburner. Because very small gas volumes are used in these systems, only small volumes of off-gas are produced. Molten solid material can be continuously removed by overflow or poured by batch to form a leach-resistant, vitrified (glassy) TRU waste form.

Vitrification

Vitrification is the process of converting materials into a glass or glass-like substance. Temperatures used in this process are typically between 1,000°C to 1,600°C (1,800°F to 2,900°F). Thermal vitrification processes destroy organic constituents by pyrolysis or combustion. These processes also immobilize inorganics by incorporating them in the glass product. Various types of electric melters could be used to vitrify TRU waste, including vertical and horizontal joule, induction, microwave, and plasma and electric arc melters.

In the joule, induction, and microwave melters, molten glass is heated internally to form a pool of molten glass in a refractory lined or "cold wall" steel vessel. In many of these melters, a cold cap, or crust, is formed on the top of the melt from the feed as it is introduced to the top of the melter. This cap would act as the interface between incoming TRU waste and the molten glass. The bottom of the cap forms an interface where the feed material melts as it enters the glass matrix. The cold cap also serves to filter particulates and to condense and retain volatilized radionuclides and heavy metals for possible reincorporation into the melt. Water and organics volatilize from the cap and enter the plenum, a pressurized enclosure where the organics may be oxidized or reformed with the steam. Organic destruction may also occur through pyrolysis in the melt or in a secondary combustion chamber.

Molten Salt

The molten salt oxidation process consists of a bath of molten salts maintained at 700°C to 950°C (1,300°F to 1,700°F) to oxidize organic components of TRU mixed waste and to retain radionuclides, metals, and acid gases in a salt residue. During operation, a mixture of liquid or solid particulate TRU waste and air is injected into the bottom of the melt which is contained in a ceramic-lined vessel. The high temperature and intimate contact with the molten salt causes the rapid reaction of the organic material with the oxygen in the air to produce conventional combustion products.

The final products of this process would be a glass or ceramic slag, a metal ingot (depending on the original TRU waste form), and treated off-gas. This treatment process would reduce the original TRU waste volume by about 35 percent or less. The glass or ceramic slag product would contain all or most of the TRU waste. The metal ingot product could be sufficiently free of radionuclides that it would be suitable for disposal as low-level waste or recycled material. In either case, the slag and potentially the metal ingot would be characterized for certification to meet the planning-basis WAC. Most materials recovered from the off-gases would be cycled to ensure their incorporation into the slag. The treated off-gas would meet facility-specific release limits, as dictated by facility permits.

2.3 STAKEHOLDER OUTREACH AND INVOLVEMENT ACTIVITIES

DOE conducted several activities prior to the SEIS-II public scoping period to inform the public of the Department's intent to prepare SEIS-II. Letters were sent to SEIS-II stakeholders, including private citizens, elected officials, tribal leaders, and public affairs officers, announcing the Department's plan to prepare SEIS-II. A Fact Sheet and the DOE Carlsbad Area Office Monthly Stakeholder Calendar for August 1995 were also distributed to stakeholders to notify the public of the upcoming SEIS-II scoping activities. In addition, an informal telephone survey was conducted to gather stakeholder suggestions about the structure of the SEIS-II scoping meetings.

SEIS-II public scoping activities included the following:

- A Notice of Intent (NOI) published in the FR on August 23, 1995 (60 FR 43779), and a notice reopening the comment period published in the FR on October 13, 1995
- A public comment period from August 23, 1995, to October 16, 1995
- Public scoping meetings held in Carlsbad, New Mexico, on September 7, 1995; Albuquerque, New Mexico, on September 12, 1995; Santa Fe, New Mexico, on September 14, 1995; Denver, Colorado, on September 19, 1995; Boise, Idaho, on September 20, 1995; and a second meeting in Denver, Colorado, on October 11, 1995

The NOI listed the times and locations of the public scoping meetings and the length of the public scoping period.

The Department issued the Implementation Plan for SEIS-II in May 1996. The Implementation Plan provides background information on WIPP, describes the Department's purpose and need for the WIPP project, and describes the SEIS-II work plan. It also describes the scoping process, major issues identified during the scoping process, and contains a brief discussion of how major scoping issues will be addressed in SEIS-II. Copies of the Implementation Plan were distributed to state, tribal and local governments, U.S. Congressional delegates from states with an interest in the WIPP project, all parties who provided scoping comments, and other interested parties.

Fact Sheets were prepared by the Department to provide stakeholders with additional information on topics related to SEIS-II. Two Fact Sheets, one on prescoping activities and the other on postscoping activities, have been distributed to parties on the SEIS-II mailing list. Fact Sheets were also distributed at the public scoping meetings. These sheets provided information on the NEPA process, the WIPP project, the DOE reading rooms, the role of public participation in the decision process, and other topics relevant to SEIS-II. The Department will also distribute Fact Sheets on the issuance of the Draft SEIS-II, completion of the Final SEIS-II, and publication of the ROD to all parties on the SEIS-II mailing list.

2.4 REFERENCES CITED IN CHAPTER 2

DOE (U.S. Department of Energy), 1980, *Final Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026, October, Washington, D.C.

DOE (U.S. Department of Energy), 1990, *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant*, DOE/EIS-0026-FS, January, Washington, D.C.

DOE (U.S. Department of Energy), 1994, *TRUPACT-II Content Codes (TRUCON)*, DOE/WIPP 89-004, Revision 8, WIPP Project Office, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995a, *Alternatives to Incineration Technical Area Status Report*, DOE/MWIP-26, April, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1995b, *Draft No-Migration Variance Petition*, DOE/CAO-95-2043, May, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995c, *Draft Waste Management Programmatic Environmental Impact Statement*, DOE/EIS-0200-D, August, Washington, D.C.

DOE (U.S. Department of Energy), 1995d, *Engineered Alternatives Cost/Benefit Study Final Report,* WIPP/WID 95-2135, September, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995e, *Radioactive Waste Processing and Volume Reduction Technology Study*, DOE/CAO-95-3102, October, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995f, *Transuranic Waste Baseline Inventory Report*, DOE/CAO-95-1121, Revision 2, December, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1995g, *Transuranic Waste Characterization Quality Assurance Program Plan*, DOE/CAO-94-1010, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996a, *Comment Responses and Revisions to the Resource Conservation and Recovery Act Part B Permit Application*, DOE/WIPP 91-005, Revision 5.2, January, Carlsbad, New Mexico.

DOE (U.S. Department of Energy), 1996b, *Waste Acceptance Criteria for the Waste Isolation Pilot Plant*, DOE/WIPP-069, Revision 5, April, Carlsbad, New Mexico.

CHAPTER 3

CHAPTER 3
DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

The following sections provide descriptions of the Proposed Action, three action alternatives, and two no action alternatives. Section 3.2.7 presents a summary table of the Proposed Action and alternatives. The Chapter closes with a discussion of the alternatives that are not analyzed in detail in this supplemental environmental impact statement (SEIS-II).

In the Notice of Intent that initiated the public scoping process for SEIS-II, the Department of Energy (DOE or the Department) preliminarily identified a Proposed Action, two action alternatives, and a no action alternative. Comments received during the scoping process identified the need for an additional action alternative and another no action alternative.

The Proposed Action, three action alternatives, and two no action alternatives presented in this chapter, therefore, comprise a wide range of options from which the Department can make decisions. Among the decisions that can be supported by these options are the following:

- Whether to open the Waste Isolation Pilot Plant (WIPP) for disposal of transuranic (TRU) waste or continue to maintain the waste in storage. The two no action alternatives examine the impacts of not opening WIPP.

- Which portions of contact-handled (CH) TRU and remote-handled (RH) TRU waste inventory (identified in Chapter 2 as the Total Inventory consisting of the Basic Inventory and Additional Inventory) should be disposed of at WIPP or continued in storage. Analyses of the alternatives include the impacts of both inventories.

- Which minimal level of waste treatment should be required in the Waste Acceptance Criteria (WAC) to meet disposal performance standards or storage requirements prior to the disposal of or storage of waste[1]. The three action alternatives differ in the treatment proposed, as do the two no action alternatives.

- Whether to transport TRU waste primarily by truck or by rail. Three transportation options (truck, commercial rail, and dedicated rail) are assessed for all alternatives except the Proposed Action, where transportation by truck is the only option considered, and No Action Alternative 2, where there is no transportation.

Decisions based on SEIS-II may be a combination of the options presented within the alternatives analyzed. This means that portions of two or more of the alternatives analyzed in SEIS-II may be combined and used by the Department for the management or disposal of TRU waste.

FURTHER NEPA ANALYSIS

The Department would conduct site-specific National Environmental Policy Act (NEPA) analyses to assess the impacts of siting and operating individual waste treatment facilities before making final decisions whether to construct and operate those facilities.

[1] DOE may decide, for site-specific reasons, to treat TRU waste to levels more intensive than the minimal level required in the planning-basis WAC. Such a decision would be based on further site-specific NEPA review.

The following sections describe the Proposed Action; Action Alternatives 1, 2, and 3; and No Action Alternatives 1 and 2.

3.1 PROPOSED ACTION: BASIC INVENTORY, TREAT TO WAC, DISPOSE OF AT WIPP

The Department's Proposed Action is to continue with the phased development of WIPP by disposing of TRU waste at the facility, as authorized by Public Laws 96-164, 102-579, and 104-201. WIPP could be ready to begin disposal by November 1997; for the purposes of analyses in this document, WIPP disposal is assumed to begin in 1998. Under the Proposed Action, DOE would dispose of defense TRU waste that has been placed in retrievable storage and that would continue to be generated from plutonium stabilization and management, environmental restoration, decommissioning activities, waste management programs, and testing and research during the 35-year period from 1998 to 2033 (i.e, waste included in the Basic Inventory). The Proposed Action is the Department's preferred alternative because it meets the purpose and need to the extent allowed by law and current agreements. Table 3-1 presents the volume of TRU waste included in this Basic Inventory. However, SEIS-II analyses were performed using the disposal volumes of 168,500 cubic meters (5,950,000 cubic feet) for CH-TRU waste (greater than the CH-TRU Basic Inventory) and 7,080 cubic meters (250,000 cubic feet) for RH-TRU waste (much less than the RH-TRU Basic Inventory) allowed by the WIPP Land Withdrawal Act (LWA) and the Consultation and Cooperation (C&C) Agreement with the State of New Mexico. The total amount of activity associated with this RH-TRU waste volume would be less than 1 million curies, far less than the 5.1 million curie limit in the LWA.

Management at WIPP of the Additional Inventory described in Chapter 2 is not analyzed as part of the Proposed Action. Alternatives for management of the Additional Inventory are presented in Action Alternatives 1, 2, 3, and No Action Alternative 1, discussed later in this chapter. Existing RH-TRU waste in the Basic Inventory that exceeds the amount allowable by current laws and agreements is identified as "excess waste." It was assumed, for the purposes of analyses, that the excess RH-TRU waste, which amounts to approximately 43,000 cubic meters (1,500,000 cubic feet), would be located at the Hanford Site (Hanford) and Oak Ridge National Laboratory (ORNL) and would remain in storage at these sites for an indefinite number of years following treatment.[1]

Current data and projections indicate that 20 sites would generate Basic Inventory waste or currently have it in storage. All such waste would first be treated at the 20 sites as necessary to meet planning-basis WAC, and then consolidated at the 10 largest generator-storage sites to await shipment by truck to WIPP for disposal. Figure 3-1 shows the flow of TRU waste between sites and shipment to WIPP. The waste treatment locations assumed for the Proposed Action are based on the Decentralized Alternative described in the *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS). SEIS-II, though, includes additional sites (DOE 1995b).

[1] DOE is not proposing to give some sites' waste higher priority for disposal at WIPP. For the purposes of analyses in SEIS-II, it was assumed that waste would be shipped from all four RH-TRU waste consolidation sites at similar rates so that the entire projected INEL and LANL RH-TRU waste volumes would be accepted, and the remaining capacity for RH-TRU waste disposal would be filled proportionally with waste from ORNL and Hanford.

Table 3-1
TRU Waste Volumes (Basic Inventory) for the Proposed Action[a]

Site[c]	Site Volume Through 2033 (cubic meters)		Pretreatment Consolidated Volume[b] (cubic meters)		Post-Treatment Disposal Volume (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU[d]	RH-TRU[e]
Hanford Site (Hanford)	57,000	29,000	57,000	29,000	57,000	42,000
Los Alamos National Laboratory (LANL)	21,000	230	21,000	230	21,000	330
Idaho National Engineering Laboratory (INEL)[f]	28,000	220	29,000	2,000	30,000	2,800
Argonne National Laboratory - West (ANL-W)	1,000	1,700	---[g]	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	200	---
Savannah River Site (SRS)	12,000	---	12,000	---	12,000	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	17,000	---
Oak Ridge National Laboratory (ORNL)	1,700	3,100	1,800	3,700	1,900	5,300
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	1,200	---
Nevada Test Site (NTS)	630	---	630	---	630	---
Mound Plant (Mound)	300	---	300	---	340	---
Bettis Atomic Power Laboratory (Bettis)	170	9	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	---	---	---	---
Energy Technology Engineering Center (ETEC)	2	7	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	---	---	---	---
Pantex Plant (Pantex)	1	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	---	580	---	---	---	---
Total	**135,000**	**35,000**	**135,000**	**35,000**	**143,000[h]**	**50,000[i]**
Disposal Volume Allowed by LWA and the Agreement for Consultation and Cooperation (C&C)	**---**	**---**	**---**	**---**	**168,500[h]**	**7,080[i,j]**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment does not necessarily include PCB-commingled waste. Volumes have been rounded. Actual totals may differ due to rounding. The site volumes through 2033 match the final columns on Table 2-2.

[b] Volumes include consolidation of waste as indicated on Figure 3-1.

[c] Sites in boldface were included in SEIS-I.

[d] Post-treatment volumes have been adjusted to meet packaging and transportation requirements to meet planning-basis WAC.

[e] Values represent WIPP emplacement volumes, except for Hanford and ORNL which may not be able to emplace all of their RH-TRU waste at WIPP.

[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, are counted as one site in SEIS-II.

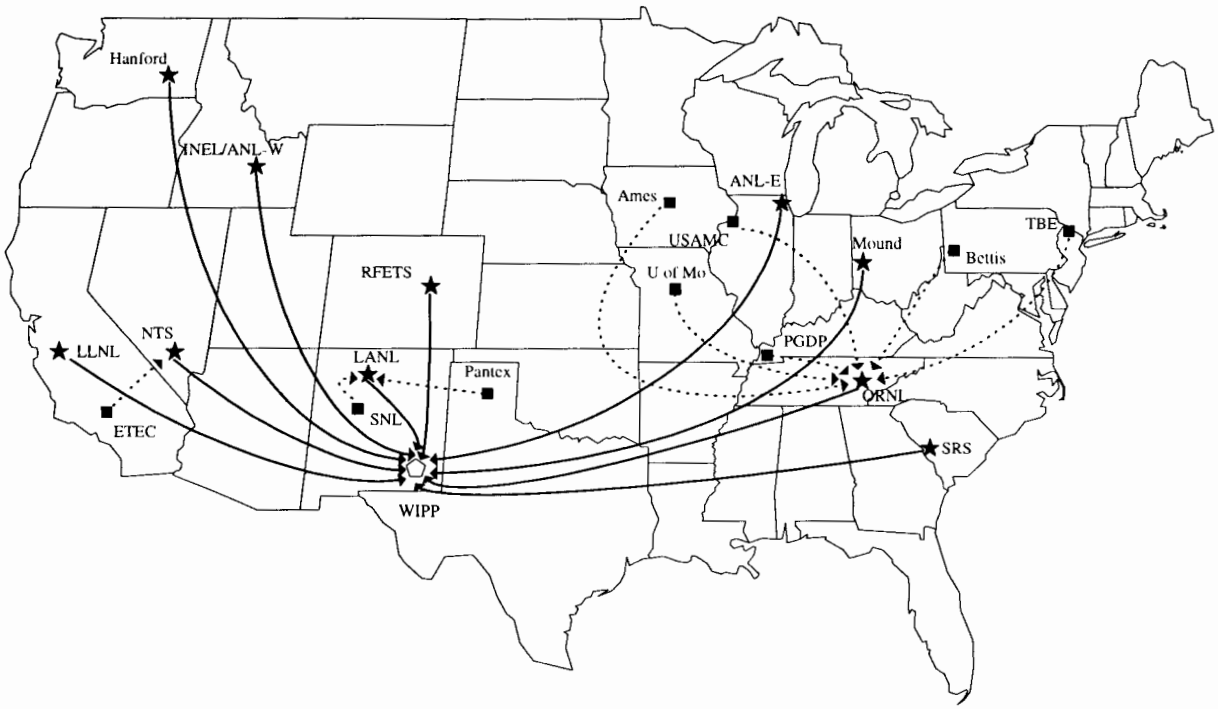
[g] Dashes indicate no waste.

[h] Though 143,000 cubic meters of CH-TRU waste are part of the Basic Inventory, additional CH-TRU waste may become a part of that inventory should RCRA or CERCLA action lead to retrieval of previously disposed of waste. Therefore, SEIS-II assesses the impact of the entire disposal volume allowed, 168,500 cubic meters.

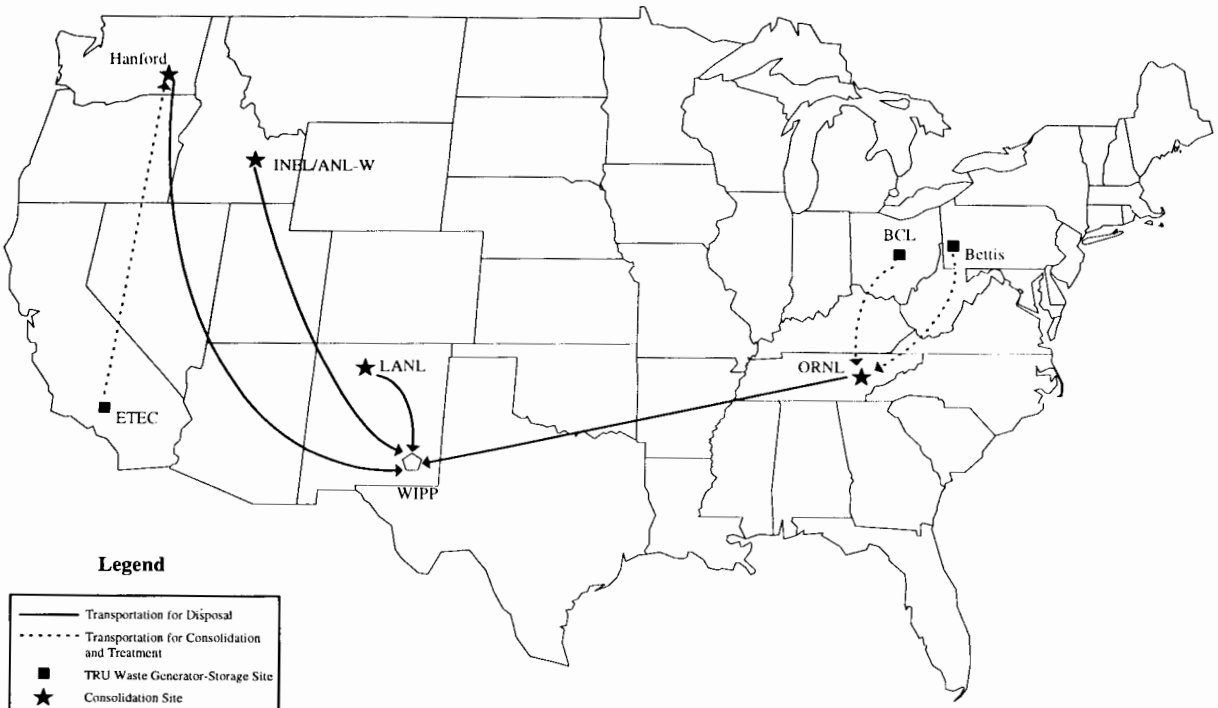
[i] All LANL and INEL RH-TRU waste is assumed to be disposed of; RH-TRU waste disposed of for Hanford would be approximately 2,800 cubic meters; that for ORNL would be 1,100 cubic meters (after consolidation).

[j] The LWA limits the total RH-TRU curie content of WIPP to 5.1 million. Under the Proposed Action, the total curie content associated with the 7,080 cubic meters would be less than 1 million curies.

CH-TRU Waste



RH-TRU Waste



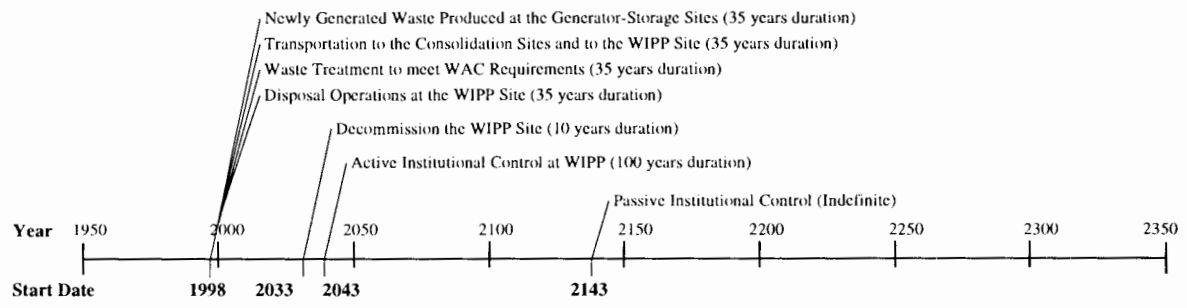
Legend

- Transportation for Disposal
- Transportation for Consolidation and Treatment
- TRU Waste Generator-Storage Site
- Consolidation Site
- WIPP

Note: Maps do not show actual transportation routes.

Figure 3-1
Movement of Waste Under the Proposed Action
(For complete names of facilities and waste volumes, see Table 3-1)

The timeline below presents the approximate schedule for waste disposal activities under the Proposed Action. The disposal of TRU waste at WIPP would begin in 1998 and continue for 35 years, through the year 2033, at which time the facility would be closed. Decommissioning activities of WIPP would take up to 10 years (2043) and would be followed by an active institutional control period assumed for analyses to last 100 years, ending in 2143.



Timeline for the Implementation of the Proposed Action

3.1.1 Activities at the Generator-Storage Sites

This section describes WIPP-related activities that would occur under the Proposed Action at various generator-storage sites throughout the DOE complex. The Draft WM PEIS and Chapter 4 of SEIS-II contain information on the sites themselves.

The 20 generator-storage sites would ship CH-TRU waste to the 10 generator-storage sites for consolidation and subsequent shipment to WIPP. Of the seven RH-TRU waste sites, three sites would ship their RH-TRU waste for treatment to meet WAC prior to shipment to WIPP. The flow of waste described here is assumed for analysis of potential environmental impacts, but the Department may adjust the configuration later in the WM PEIS Record of Decision.

The type of treatment performed at the treatment sites would depend on whether the waste is already certified as meeting WAC. Some waste may require treatment and packaging to meet WAC. All waste has been assumed to be treated and packaged to planning-basis WAC (using mobile treatment units where appropriate).[1] This could include, for example, reducing size and packaging, adding absorbents to eliminate free liquids, packaging, and assaying and sampling to ensure that packaging and transportation certification criteria have been met. Each site preparing to ship TRU waste to WIPP would coordinate with WIPP personnel for scheduling purposes. Together, site and WIPP personnel would arrange for shipment from the site to WIPP using either the TRUPACT-II or the RH-72B cask.

[1] At the smaller sites, use of mobile characterization and/or treatment units was assumed. Any emissions from these mobile units would be HEPA (High Efficiency Particulate Air) filtered. The characterization, packaging, and treatment performed by the mobile units would be expected to produce no additional waste, and virtually no radiological or hazardous chemical impacts to workers or the public would be expected.

CONSERVATISM OF TRU WASTE INVENTORY ESTIMATES

TRU waste inventory estimates, as used throughout the SEIS-II analyses, embody many conservative assumptions to ensure bounding analyses of maximum, reasonably foreseeable impacts. The following reflect some of the conservative assumptions.

- The latest estimates of TRU waste volumes (i.e., those which are reported in the *Transuranic Waste Baseline Inventory Report*, Revision 2 [BIR-2]) include projections that may overestimate TRU waste volumes. For instance, in both the Basic Inventory and the Additional Inventory, volume estimates include projections of waste yet to be generated. Though the Department's TRU waste generation due to defense activities has decreased because of a change in the nation's nuclear weapons needs, the projections of future waste also include waste anticipated by such activities as decontamination and decommissioning. These activities, which would include cleaning and disassembling facilities, can generate a great deal of TRU waste, but whether that waste will actually be generated and whether it will be CH-TRU or RH-TRU waste is uncertain. For the purposes of analyses, SEIS-II has used the estimates included in BIR-2, which were provided by each facility based upon current plans.

- The Additional Inventory includes estimates of TRU waste produced prior to 1970 and believed to have been disposed of in trenches at some of the sites. Since DOE's definition of TRU waste has changed and some of the buried waste would probably be classified as low-level waste under current definitions, the amount of this waste that is actually TRU waste is unknown. For the purposes of analyses, all of this waste, as estimated in BIR-2, is considered part of the Additional Inventory and the effects of its disposal at WIPP are assessed in the SEIS-II action alternatives. SEIS-II analyzes 141,000 cubic meters (5 million cubic feet) of TRU waste that has been previously disposed of. Currently, though, DOE estimates that only 80,000 cubic meters (2,830,000 cubic feet) of this waste would be excavated.

- The Agreement for Consultation and Cooperation (C&C Agreement) between the State of New Mexico and DOE limits the amount of RH-TRU waste allowable at WIPP to 7,080 cubic meters (250,000 cubic feet). The Department's Proposed Action proposes disposing of this amount of RH-TRU waste. The actual amount of RH-TRU waste disposed of may, however, be as low as 4,300 cubic meters (150,000 cubic feet). This is because current plans call for disposing of this waste in the walls of WIPP panel rooms before emplacement of CH-TRU waste in the rooms. At startup, delays in preparing the RH-TRU waste for shipment are anticipated, which would result in the emplacement of some CH-TRU waste before RH-TRU waste is ready for WIPP. To ensure that SEIS-II disposal analyses are conservative, the analyses for the Proposed Action were conducted as if the full 7,080 cubic meters of RH-TRU waste would be emplaced.

- Application of the LWA and the C&C Agreement would limit the amount of CH-TRU waste allowable under the Proposed Action to 168,500 cubic meters (5,950,000 cubic feet), but only 143,000 cubic meters (5,050,000 cubic feet) is estimated to be in the Basic Inventory. Still, because of the potential for excavation of previously disposed of waste (which would then be classified as newly generated) and the potential for treatment of alpha-emitting low level waste that could convert currently non-TRU waste forms into TRU waste (as discussed in the cumulative impacts analysis), SEIS-II analyses consider the effects of filling WIPP to its allowable capacity.

- BIR-2 estimates indicate that about 60 percent of the nation's TRU waste is TRU mixed waste, with constituents that would be hazardous. Under some of the alternatives considered for SEIS-II, this waste would be treated to remove many of the hazardous constituents that make it mixed waste and would be reduced in volume. For the purpose of analysis of impacts from treatment, it was assumed that 100 percent of the TRU waste would be treated as TRU mixed waste and reduced in volume.

- While the LWA and C&C Agreement include limits on the volume of TRU waste that can be emplaced, there is considerable uncertainty concerning how much of a container's volume is made up of TRU waste and how much is void space. Many of the containers would include a great deal of void space, particularly for RH-TRU waste; the actual volume of waste in a drum or cask, therefore, may be much less than the volume of the drum or cask. For the purposes of analyses in SEIS-II, the volume of the drum or cask is used.

While volume changes to the TRU waste inventory could reduce or increase the effects calculated in SEIS-II, the best estimates available have been used and conservative assumptions have been incorporated to ensure that the results would actually be less than those presented. A box similar to this one, entitled "Factors to Consider in Combining Alternatives" (presented in Chapter 5), explains in more detail how the results would change as inventory volumes change.

3.1.2 Transportation Activities

Under the Proposed Action, trucks transporting TRU waste in U.S. Nuclear Regulatory Commission (NRC)-certified transportation containers and traveling over U.S. Department of Transportation (DOT) and state-designated routes would transport the TRU waste between the generator-storage sites and from the consolidation sites to WIPP. Trucks would transport CH-TRU waste in TRUPACT-IIs and RH-TRU waste in RH-72B casks (see the textbox on page 2-3). The rate at which both CH-TRU waste and RH-TRU waste would arrive at WIPP for disposal would be based on the WIPP waste handling throughput rate and the storage area. On average, WIPP facilities would handle about 50 TRUPACT-IIs of CH-TRU waste and about eight RH-72B casks of RH-TRU waste per week. There is little capacity at WIPP to backlog shipments, and DOE proposes to obtain the Resource Conservation and Recovery Act (RCRA) permits for limited nonroutine storage capacity in the Waste Handling Building (see Figure 2-3). Further, the time that incoming waste can spend in the staging area is limited. The Safety Analysis Report for Packaging attached to Certificate of Compliance No. 9218 (NRC 1989) limits the time a TRUPACT-II can remain sealed (with waste inside) to a maximum of 60 days, due to the potential for hydrogen gas accumulation within the TRUPACT-II. WIPP operations managers would meet these requirements through continuous coordination with the treatment sites to control the time and rate at which CH-TRU and RH-TRU waste arrives at WIPP for disposal.

Currently, the Department is proposing the use of trucks to transport waste. The Department has investigated and continues to investigate the possibility of using rail transportation but considers it less reasonable at this time. The primary factors that make rail carriage less reasonable are the following: (1) limited interest of the rail carriers in handling the shipments, (2) higher cost of dedicated rail transportation as compared to truck transportation (3) the initial cost of acquiring additional TRUPACT-IIs needed for rail transportation (because three times as many TRUPACT-IIs would be needed for each shipment), and acquiring or modifying rail cars for transport, and (4) DOE's inability to obtain rail carrier assurance that TRUPACT-II transit will enable DOE to unseal the TRUPACT-II within 60 days, as required by NRC. Regular rail transportation, because of its lower cost and accident risk, is still considered a desirable option for some waste transportation in the future, provided the factors that make it currently less reasonable can be mitigated, and it is analyzed as part of the alternatives to the Proposed Action.

3.1.2.1 Shipping Procedures

The DOE *Transuranic Materials Transportation Guide* (DOE 1996c) prescribes the procedures to be followed for shipping TRU waste; essentially, these are the same procedures planned earlier and reported in the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990). DOE personnel, the generator-storage sites, and the carriers would comply with all applicable rules, regulations, and orders pertaining to the packaging, marking, labeling, inspection, and transportation of TRU waste as issued by the DOT, DOE, the U.S. Environmental Protection Agency (EPA), and NRC.

Each generator-storage site would ensure that the TRU waste to be shipped meets WAC, that the waste is properly loaded into the TRUPACT-II or RH-72B casks, that all DOE procedures have been followed, that labels and placards are in compliance with DOT regulations, and that bills of lading are entered correctly into the Transportation Tracking and Communications (TRANSCOM) system. The Department would be prepared to provide emergency response support in the event of an accident.

A contract carrier would provide dedicated drivers and tractor-trailer trucks to transport TRU waste to WIPP. The trailers and packagings are owned by DOE. Specific responsibilities of the carrier would include providing drivers who are qualified according to DOT requirements (Title 49, Code of Federal Regulations [CFR] Part 391) and ensuring that vehicles are operated in a safe manner. The carrier would ensure that both the tractor and the trailer are in operating condition prior to leaving the shipper's premises and during the trip. Drivers would be required to make routine visual safety inspections of the tractor, trailer, and containers either every 160 kilometers (100 miles) or every two hours, in addition to routine inspections required by DOE, DOT, and affected states. Carriers would keep current copies of their maintenance certificates in their vehicles at all times.

In the event of an accident, the carrier driver would notify emergency first-responders via cellular phone and would notify the Central Monitoring Room (CMR) at WIPP via TRANSCOM. A senior DOE official or the DOE Carlsbad Area Office (CAO) Incident/Accident Team Leader would assist those in charge at the accident. DOE resources would be made available to local authorities, as appropriate, to support the mitigation of the accident, including, but not limited to, package recovery and site cleanup. In the event of an accident involving a fire, breach, release, or suspected radioactive contamination, the carrier would follow established procedures to obtain any needed federal, state, or local assistance or technical advice. Drivers would carry instructions for actions to be taken in the event of an accident and would be trained in package recovery procedures (see Appendix E). Any carrier accident, no matter how minor, would be reported to the CAO Transportation Manager, the WIPP Traffic Manager, the CMR operator, and DOE Headquarters Emergency Operations Center via the DOE Albuquerque Operations Office. If not already notified by the carrier, the shipper would be notified by the CMR operator.

TRANSCOM SYSTEM

DOE has developed a transportation tracking and communications system that is used to track truck and rail shipments. This satellite-based system, the Transportation Tracking and Communications (TRANSCOM) system, has been in operation since 1989. Since its inception, the TRANSCOM System has tracked over 500 shipments for DOE. The use of TRANSCOM is mandated by DOE Order 460.2, *Departmental Materials Transportation and Packaging Management*.

The mission of the TRANSCOM system is to provide tracking and communications for shipments of radioactive materials, hazardous materials, and other high-visibility shipping campaigns, as specified by DOE. The TRANSCOM system is managed and operated at the TRANSCOM Control Center (TCC) in Oak Ridge, Tennessee, for DOE.

The TRANSCOM system provides the TCC staff, shippers, carriers, receivers, and state, Tribal, and federal users with the ability to view information about shipments and communicate with each other during shipment tracking. Information about shipment contents, points of contact, routes, status, locations, and emergency response information is available to local emergency response teams and each user. The information is displayed in tabular and graphical form using a series of national, state, and county maps. The vehicle location can be determined to within a few meters, with position updates as frequently as every 60 seconds. Drivers are alerted to adverse weather or road conditions.

Delays in scheduled arrival may occur from time to time due to weather conditions, maintenance checks, and other factors at the treatment sites. All schedule delays of two or more hours from the shipping, receiving, or transit time would be reported immediately to the CMR, which would notify the shipper or receiver, as appropriate. If a shipment were delayed, a new scheduled time of arrival would be arranged. There would be no "deadlines" for a shipment to be received at WIPP.

The carrier's management plan provides guidance from the Western Governors Association and DOE on the selection of suitable safe parking areas. As instructed, carriers would use designated DOE or Department of Defense sites, or an area designated by the affected state as a safe parking area, in the event of a shipping layover. If no DOE, Department of Defense, or state-designated site were available, the driver would select a site based on criteria related to the nearby population size, proximity, and security and would notify the nearest state police district office.

3.1.2.2 Shipping Routes

Under the Proposed Action, transportation would include shipments between the generator-storage sites and from the 10 largest generator-storage sites to WIPP. The states through which the trucks would pass would designate shipment routes in consultation with DOE. Figures in Appendix E show the currently designated routes. These routes, as well as any chosen in the future, would comply with DOT requirements, use the Interstate Highway System or other state-designated roads and use the shortest routes to access the interstate highways. The routes also would bypass urban areas if this could be done safely and efficiently.

3.1.3 Activities at WIPP

At the time of SEIS-I (DOE 1990), all surface facilities, shafts, and hoist facilities had been constructed. Underground, an initial waste disposal panel (Panel 1) had been excavated and was ready to accommodate the Test Phase activities (see Section 2.1.4). These physical facilities, which are described in SEIS-I, are essentially unchanged.

3.1.3.1 Excavation Operations

Under the Proposed Action, a total of ten panel-equivalents (in the panels and access tunnels) would be needed to dispose of the waste. DOE has excavated the first panel, which consists of seven disposal rooms and, from an engineering viewpoint, could receive waste now. The Department would excavate the additional disposal panels as needed. The Department estimates that it would require up to three years to excavate a panel.

The massive saltbeds at a depth of 655 meters (2,150 feet) creep slowly in response to pressure from the overlying rock and would eventually cause the excavated openings within the salt beds to close. This is the reason why "just-in-time excavation" would be used. Just-in-time excavation is based on the concept that when additional room is needed for waste disposal, a new panel would be excavated and ready for use "just in time." This means that each panel would be excavated, filled, and closed in a time frame that would minimize the potential for hazardous conditions such as roof falls.

The Department would maintain each excavation (e.g., panel room) until it is filled. Personnel working underground would conduct a monitoring and excavation maintenance program in compliance with a long-term ground control plan (WID 1995). In addition to regular visual inspections, geotechnical instrumentation would provide continuous information about rock mass movement and deformation. Every underground worker would have the responsibility and authority to close a suspect area to entry until it has been inspected by excavation safety personnel. Unsafe or potentially unsafe areas would be remediated by bringing down loose rock or installing control measures such as wire mesh and roof bolts. The facilities would be inspected a minimum of four times a year by the Mine Safety and Health Administration.

Salt that results from the excavation of the panels would be stored aboveground in the existing salt pile, which would be 12 hectares (30 acres). Management of the salt pile may include selling or disposing of unneeded salt under the Materials Act of 1947. The salt pile would stabilize naturally, and a drainage pond would contain runoff. Salt would be retained at the site for potential use in permanent shaft seals and other markers upon closure of WIPP.

3.1.3.2 TRU Waste Handling Operations at the Surface

CH-TRU waste would arrive at WIPP on tractor-trailer trucks, each of which can carry up to three TRUPACT-IIs. Thus, each truck shipment could deliver up to forty-two 55-gallon drums, six standard waste boxes of CH-TRU waste, or three Ten Drum Overpacks. RH-TRU waste would also arrive by truck. Each truck could carry one RH-72B cask. Each cask contains a canister holding up to three 55-gallon drums of RH-TRU waste or up to 0.89 cubic meters (31 cubic feet) if drums are not used inside the canister.

For CH-TRU waste, the Department has developed detailed procedures for unloading the trucks, opening the TRUPACT-IIs, inspecting the packages, preparing packages to be moved underground, and then moving them to the underground. Conceptually, the process is as follows: When a truck arrives at the Waste Handling Building, it would be inspected for load integrity and the presence of radioactive contamination. The truck would be unloaded, and the TRUPACT-IIs moved to a specially designed platform with equipment and testing facilities. Each time another barrier surface of the container assembly was uncovered, the waste packages would be checked for surface radiation levels and contamination before the packages are placed on pallets for transport to underground emplacement.

Shipping packages or waste containers with surface contamination less than or equal to 20 disintegrations per minute alpha or 200 disintegration per minute beta/gamma would not need to be decontaminated prior to handling. If surface contamination on the exterior of the shipping package or waste container is detected in amounts less than 2,000 disintegrations per minute alpha or 20,000 disintegrations per minute beta/gamma over an area less than or equal to 0.56 square meters (6 square feet), the shipping package or waste container would be decontaminated prior to any further steps in the waste handling process (DOE 1996a). If surface contamination in excess of these levels was detected, the canister or drums would be put into an outer sleeve and a lid would be welded on using remote handling equipment. The shipping package or waste container would either be returned to the treatment site, shipped to a different DOE site if the original shipper does not have suitable facilities, or shipped to a non-DOE site for decontamination. In all cases, the waste would be packaged and certified prior to return shipment to WIPP. In the unlikely event that the external surface contamination is too great to allow safe return and transportation to a shipping site, DOE would take necessary isolation, safety, and decontamination measures. DOE could potentially dispose of any such packages or containers in WIPP, upon appropriate RCRA Part B Permit modification.

The Department proposes to use backfill material, with components added that would minimize the mobility of radionuclides during the repository's post-closure phase, to aid in complying with the requirements of 40 CFR Part 191.13. The mobility of radionuclides, which is determined in part by their solubility in brine, is dependent on the physical and chemical conditions present in the repository, particularly those anticipated as a result of gas generation from the degradation of waste. The purpose of the added component (magnesium oxide) is to react with the brine in such a way that radionuclide solubility and, therefore, the mobility are lowered. Details on the theory behind the current plans for this backfill are described in Appendix D22 of the WIPP RCRA Part B Permit Application (DOE 1996a).

The backfill, in mini sacks of polyethylene or other suitable material, would be manually emplaced in the external voids of each 7-pack unit (a collection of seven drums) just before the 7-pack is positioned on the waste stack. A similar process would be used for standard waste boxes, except that the mini sacks would be hung from the lift clips on these units.

For RH-TRU waste to be shipped in the RH-72B cask, the Department would not finalize the waste handling operations procedures until the NRC certifies the RH-72B transportation cask. In general, the procedures would be similar to the sequence described for the CH-TRU waste and the TRUPACT-II. One difference would be that RH-TRU waste would be handled in canisters made of quarter-inch steel with welded lids. Using remote manipulators, the RH-TRU waste canisters would be removed from the RH-72B casks and placed in a room specially designed for shielding radiation. Subsequent testing operations would be conducted in this room until the canisters would be sent down the waste handling shaft.

3.1.3.3 Emplacement Operations for CH-TRU Waste

At the repository horizon station of the waste handling shaft, specially designed transporters would take the CH-TRU waste pallets from the shaft to the disposal room. Forklifts with a specially designed handling mechanism would then remove the waste from the transport pallets and stack the waste packages three high, leaving up to 1.2 meters (4 feet) of room for ceiling clearance. Each disposal panel would accommodate approximately 81,000 55-gallon drum equivalents (both drums and waste boxes will be used for disposal) equivalent to 16,700 cubic meters (590,000 cubic feet) of CH-TRU waste. As noted above, DOE would coordinate filling the disposal rooms with RH-TRU waste because the RH-TRU waste would be placed in the walls before filling each room with CH-TRU waste.

In addition, supersacks containing magnesium oxide backfill would be handled and placed with the same technique as used for normal waste handling operations. Once each row of waste units is in place, a layer of six supersacks would be placed on top of them. Finally, magnesium oxide minisacks would be manually stacked on the floor in the space between the waste stack and the panel wall, placed horizontally or vertically as may be convenient. Backfill placed in this manner would remain protected until exposed when sacks are broken during creep closure of the room and compaction of the backfill and waste.

After each panel has been filled, it would be closed using the panel closure system. For the purposes of analyses, the system would be considered passive and consist of either a standard rectangular concrete barrier or an enlarged, tapered concrete barrier. The barrier would be emplaced in both the panel air-intake and air-exhaust tunnels and contact-grouted at the interface between the barrier and the tunnel walls. Contact-grouting involves filling the void spaces. The panel closure system has been designed to add a margin of assurance to limit the migration of hazardous constituents (Appendix I of the RCRA Part B Permit Application) during the 35-year operational and facility closure period and to withstand a potential methane explosion from the accumulation of gas in the panel.

3.1.3.4 Emplacement Operations for RH-TRU Waste

For shielding purposes, the RH-TRU waste canisters would be placed into horizontal boreholes in the walls of the disposal rooms and access tunnels. The horizontal emplacement holes, about 0.9 meters (3 feet) in diameter, would be drilled on 2.4-meter (8-foot) centers to a depth of 4.9 meters (16 feet). Additional holes would be placed in the access tunnels at each end of the disposal rooms. Specially designed insertion equipment would be used to place the RH-TRU canisters at the back of the horizontal drill holes and then plug the holes with a massive

carbon-steel plug. Once the RH-TRU waste emplacement holes in a disposal room were all used and closed, emplacement of CH-TRU waste in the access tunnel itself would begin (DOE 1995a).

Each disposal panel would accommodate about 730 canisters, equivalent to 649 cubic meters (22,900 cubic feet) of RH-TRU waste. The SEIS-II analyses are based on the assumption that 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste would be disposed of. The greater volume of RH-TRU waste in SEIS-II than that used for the RCRA Part B Permit Application (DOE 1996a) would be disposed of in the access tunnels, Panels 9 and 10. To account for this difference, these panels would each need to be modified to accommodate 1,060 canisters, equivalent to 944 cubic meters (33,000 cubic feet).

3.1.3.5 Closure and Decommissioning

Under the Proposed Action, WIPP would receive and dispose of TRU waste for 35 years through the year 2033. This time for disposal is 10 years longer than that anticipated in SEIS-I because the Department now has more complete information on the TRU waste inventory (see Appendix A) and revised estimates of the time needed to treat the waste to meet planning-basis WAC.

DOE would close the repository when WIPP achieves a capacity of 175,600 cubic meters (6.2 million cubic feet) of TRU waste. Final facility closure would include the placement of a repository sealing system. As explained in more detail in the RCRA Part B Permit Application (DOE 1996a), the planned repository sealing system would consist of natural and engineered barriers within the WIPP repository that would prevent water from entering it and impede gases or brines from migrating out. The seal design for the repository shafts would use materials that may include highly compacted crushed salt, clay, concrete, and asphalt. The salt, when consolidated over time, would preclude the downward flow of groundwater into the repository and the upward movement of brine or gas that may be contaminated.

The Department would decommission the site in a manner that would allow for safe, permanent disposition of surface and underground facilities, which would be consistent with the then-applicable regulations. Little or no contamination of facilities would be expected, although equipment and facilities would be decontaminated as necessary. Useable equipment would be removed and surface facilities dismantled. A berm would be constructed around the perimeter of the closure area, which would include 60 hectares (150 acres). The area above the 10 panel equivalents would be 40 hectares (100 acres), the area of the salt pile would be 12 hectares (30 acres), and the area of the surface facilities would be 8 hectares (20 acres). The height of the berm would be sufficient to identify the closure area and impede access. DOE would restore the areas occupied by the salt pile and surface facilities and, if necessary, any of the area overlying the disposal panel area, although surface disturbance of this area would be minimal. This decommissioning period is anticipated to take up to 10 years. Any salt remaining after WIPP closure and construction of the berm would be sold or disposed of in accordance with the Materials Act of 1947.

There are no changes since SEIS-I to the anticipated long-term controls for the WIPP site after the Department closes it, which would include active controls, monitoring, and passive controls. The 100-year active institutional control period would extend through the year 2143, during which the Department would use a fence and an unpaved roadway along the perimeter of the repository surface footprint area (the waste disposal area projected to the surface) to control access. The fence line would be posted with signs that warn of the danger and state that access by unauthorized persons is prohibited. Routine, periodic patrols and surveillances of the protected area would be

conducted as well as periodic inspection and necessary corrective maintenance of the fence, signs, and roadway. In addition, the Department would prohibit drilling within the LWA to preclude inadvertent intrusion into the repository.

The Department would place a number of permanent markers to inform and warn subsequent generations that radioactive wastes are buried there. This permanent marker system would be designed to minimize the likelihood of human intrusion. Current plans include markers that would do the following:

- Identify the site
- Relay warning messages
- Use multiple methods for marking the site
- Use multiple means of communications (e.g., language, pictographs, scientific diagrams)
- Use multiple levels of complexity within individual messages on individual marker system elements
- Construct markers with materials of little intrinsic value

Other actions under consideration by DOE are the following:

- Construction of an earthen berm to indicate the subsurface disposal area perimeter of the 60-hectare (150-acre) WIPP site
- Construct an "information center," located in the middle of the area, with more information on the type of waste disposed of at WIPP, why the waste is dangerous, and why TRU waste should not be disturbed
- Place additional warning messages approximately 6 meters (20 feet) beneath the surface, within the perimeter
- Place large permanent magnetic materials and radar reflectors within the berm so that the site could be remotely detected
- Have off-site archival records at several local, state, and federal organizations

Retrieval and removal of TRU waste (as discussed in 40 CFR Part 194) is discussed in Section 5.7.

3.2 ALTERNATIVES

SEIS-II analyzes a total of five alternatives to the Proposed Action, including two no action alternatives. The following sections describe these alternatives. A summary table is presented at the end of this section.

3.2.1 Action and No Action Alternatives

DOE identified the alternatives to the Proposed Action for analyses according to Council on Environmental Quality (CEQ) guidance (46 FR 18026), which indicates that an agency should consider alternatives that are practical or feasible from the technical and economic standpoint and using common sense. Using this guidance and considering the LWA requirement that the Department make recommendations for the disposal of all DOE-owned or controlled TRU waste, it is reasonable to examine alternatives that include disposing of all DOE-owned or controlled TRU waste at WIPP. In addition, the CEQ regulations implementing NEPA require a No Action Alternative (40 CFR Part 1502.14 (d)). DOE recognizes that these alternatives may, at least in part, require amendment of existing laws or agreements negotiated with EPA and/or involved states. Nevertheless, under NEPA, DOE is required to consider reasonable alternatives even if they are in conflict with existing law. The fact that DOE is considering these alternatives for the NEPA process should not be construed as meaning that the Department intends to implement any action that would violate the law or violate legally binding agreements negotiated pursuant to law.

The number of disposal panels required for each alternative is influenced by the 10,000-watt-per-surface-acre design limit on heat load for waste disposed of at WIPP. Consistent with the RCRA Part B Application, an average heat load of 60 watts per RH-TRU waste canister is assumed for the Proposed Action and the alternatives (the actual heat load has been calculated at about 1 watt per canister). Additional mining would be necessary under the action alternatives to distribute the RH-TRU waste as required by the surface acre thermal power limitations. The operational time periods for the action alternatives are driven by current maximum RH-TRU waste emplacement and/or mining rates, which are used only to make the alternatives easily comparable to each other and the Proposed Action. If any of the action alternatives were chosen, waste handling and mining operations could be modified to allow shorter operational time periods, and actual RH-TRU waste heat loads would probably require less mining than that assumed for the alternatives.

3.2.2 Action Alternative 1: Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP

For this alternative, WIPP would accept all TRU waste for disposal, which would include the Basic Inventory with the excess RH-TRU waste plus the Additional Inventory without TRU waste commingled with polychlorinated biphenyls (PCB). The waste would be treated to planning-basis WAC and then shipped to the 10 sites with the largest volumes of waste for consolidation. PCB waste would continue to be managed at the generator sites. Table 3-2 presents the CH-TRU waste volumes, and Table 3-3 presents the RH-TRU waste volumes for Action Alternative 1. These tables list the site volume, pretreatment volume, and post-treatment volume for the Basic Inventory, Additional Inventory, and the combined total (Total Inventory) for each treatment site. DOE could not dispose of some of these additional waste types at WIPP under the current laws and agreements that regulate WIPP. Figure 3-2 shows the flow of TRU waste between sites and shipment to WIPP for Action Alternative 1.

Table 3-2
CH-TRU Waste Volumes for Action Alternative 1[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	57,000	63,000	120,000	57,000	63,000	120,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	21,000	14,000	35,000
Idaho National Engineering Laboratory (INEL)[f]	28,000	57,000	85,000	30,000	57,000	86,000	30,000	57,000	87,000
Argonne National Laboratory - West (ANL-W)	1,000	---[g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	200	---	200	200	---	200
Savannah River Site (SRS)	12,000	4,900	17,000	12,000	4,900	17,000	12,000	4,900	17,000
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	17,000	---	17,000
Oak Ridge National Laboratory (ORNL)	1,700	56	1,700	1,800	260	2,100	1,800	260	2,100
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	1,200	---	1,200	1,200	---	1,200
Nevada Test Site (NTS)	630	---	630	630	---	630	630	---	630
Mound Plant (Mound)	300	---	300	300	---	300	340	---	340
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**136,000**	**273,000**	**135,000**	**138,000**	**273,000**	**143,000**	**138,000**	**281,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-2.

[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is not included.

[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

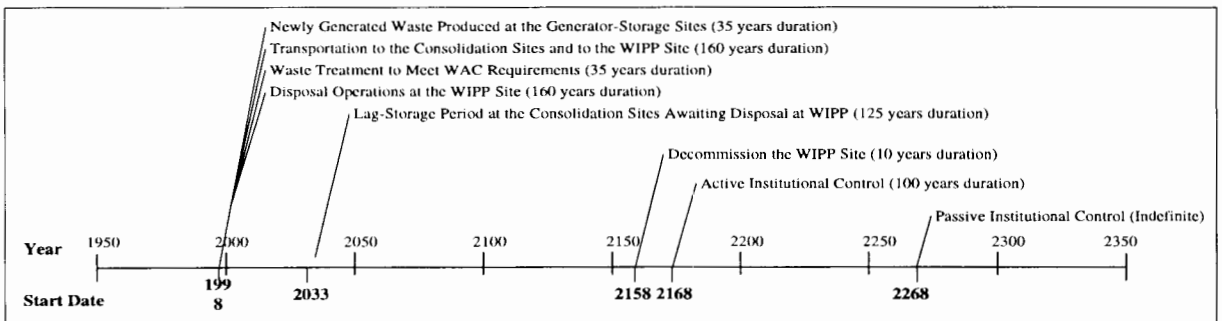
[g] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.

Table 3-3
RH-TRU Waste Volumes for Action Alternative 1[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	29,000	1,000	30,000	42,000	1,500	43,000
Los Alamos National Laboratory (LANL)	230	120	350	230	120	350	330	170	490
Idaho National Engineering Laboratory (INEL)[f]	220	440	660	2,000	440	2,400	2,800	630	3,400
Argonne National Laboratory - West (ANL-W)	1,700	---[g]	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	2,000	5,600	5,200	2,700	8,000
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	80	80	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**50,000**	**5,000**	**55,000**

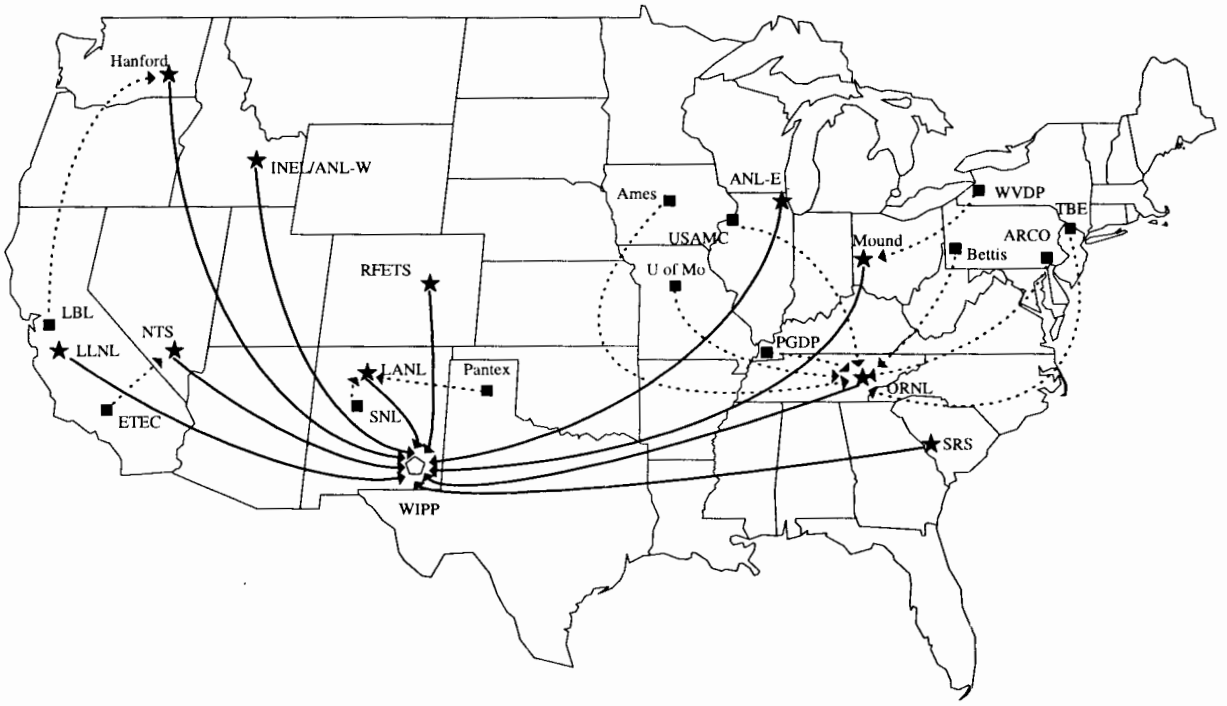
[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-2.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is not included.
[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.

A timeline below presents the approximate schedule for waste disposal activities under Action Alternative 1. Sites would generate waste for 35 years, beginning in 1998. The disposal of TRU waste at WIPP would begin in 1998 and continue for approximately 160 years, ending in 2158. The duration of disposal operations for Action Alternative 1 is based on the time needed to emplace the total volume of RH-TRU waste, assuming maximum emplacement rate of 356 cubic meters (12,570 cubic feet) per year, a throughput rate of eight RH-72B canisters per week (DOE 1996c), and an operating time of 50 weeks per year. Decommissioning activities would last for up to 10 years and would be followed by an active institutional control period assumed for analyses to last 100 years, ending in 2268.

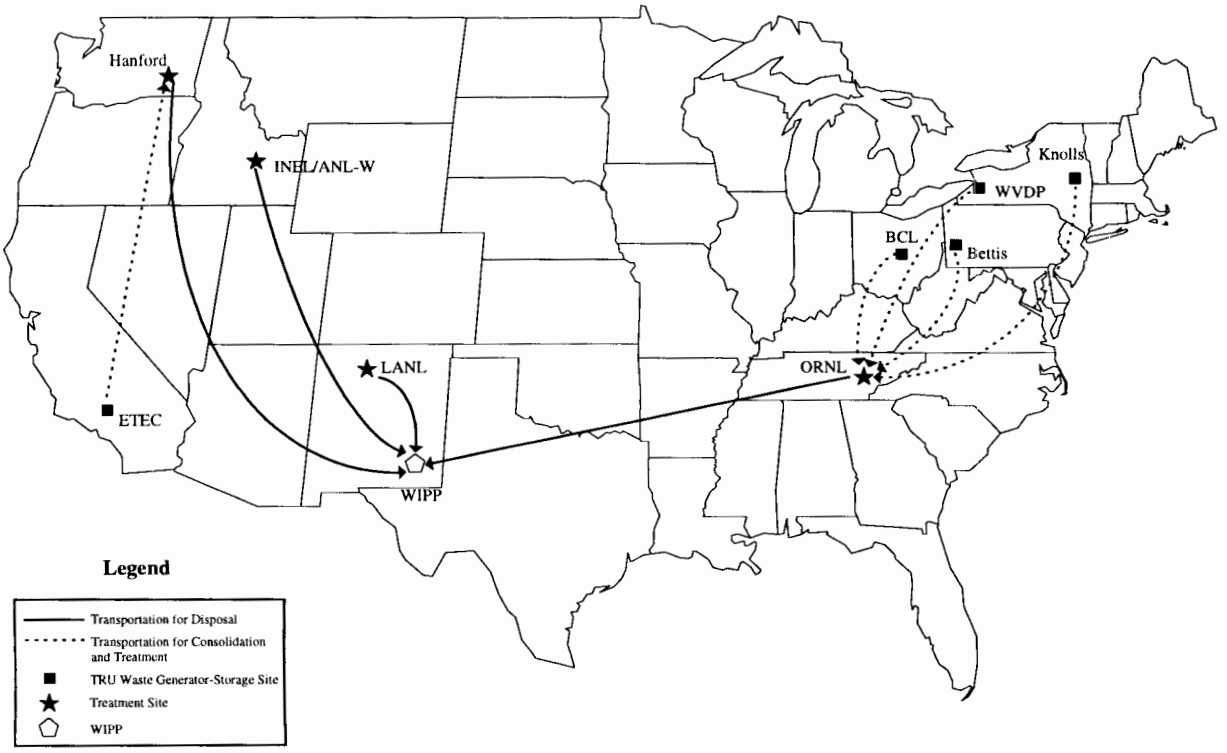


Timeline for the Implementation of Action Alternative 1

CH-TRU Waste



RH-TRU Waste



Note: Maps do not show actual transportation routes.

Figure 3-2
Movement of Waste Under Action Alternative 1
(For complete names of facilities and waste volumes, see Tables 3-2 and 3-3)

3.2.2.1 Activities at the Generator-Storage Sites

The activities at the generator-storage sites would be the same as those described for the Proposed Action, except that they would involve approximately twice as much waste. The volumes shown in Tables 3-2 and 3-3 reflect the currently stored and projected volumes and the volumes after any packaging and treatment necessary to meet planning-basis WAC. The generator-storage sites would consolidate all CH-TRU waste at 10 treatment sites after treating the waste to meet WAC for subsequent shipment to WIPP. The generator-storage sites would ship RH-TRU waste to four treatment sites to meet WAC for subsequent shipment to WIPP. Waste treatment would occur over 35 years, through the year 2033. Although all of the TRU waste could be treated and packaged by 2033, much of the waste would be placed in lag storage at the treatment sites awaiting shipment to WIPP.

3.2.2.2 Transportation Activities

Transportation activities under this alternative would differ from those described for the Proposed Action in the following ways:

- Almost three times as many shipments would be required to ship the CH-TRU and RH-TRU waste to WIPP, due mainly to the additional RH-TRU waste to be shipped to WIPP under Action Alternative 1 (almost eight times more).

- The period of shipping to consolidation sites and to WIPP would extend for 160 years, through the year 2158.

- TRU waste may be shipped by truck and by commercial and dedicated rail from the 10 major treatment sites to WIPP. SEIS-II analyses for this alternative include three transportation scenarios. The first scenario uses trucks only, as described under the Proposed Action. The other two scenarios use a mix of commercial rail and truck or dedicated rail and truck. Rail would be used to the maximum extent practicable, and thus the term "maximum rail" is used to connote the emphasis on rail use. Trucks would be used instead of rail from Los Alamos National Laboratory (LANL) and the Nevada Test Site (NTS) because railroads do not currently exist from those sites. DOE would not build new rail lines. WIPP already has a rail spur leading to the facility.

3.2.2.3 Activities at WIPP

Under Action Alternative 1, excavation operations, TRU waste handling operations at the surface, CH-TRU waste emplacement operations, closure, and decommissioning would be the same as those for the Proposed Action. This alternative would extend the operations time frame to as late as the year 2158, and WIPP would accept a larger total volume of TRU waste. A total of 68 panels would be excavated to accommodate the additional waste with 17 panels to accommodate CH-TRU and RH-TRU waste, 51 panels for RH-TRU waste only (due to a 10,000 watt-per-acre limit). Any expansion of WIPP capacity beyond current limits would require changes to the LWA and the C&C Agreement, as well as permits to operate WIPP.

As with the Proposed Action, RH-TRU waste canisters would be emplaced in horizontal boreholes in panel walls. Other RH-TRU waste disposal options may be considered, including vertical boreholes or trenches in the floors of disposal rooms. In addition, waste currently considered to be RH-TRU waste at the generator-storage sites may be packaged there to meet CH-TRU waste requirements, not exceeding a dose rate of 200 millirem per hour at the container surface. This waste would then be emplaced as CH-TRU waste at WIPP.

Closure and institutional controls would be the same as those for the Proposed Action, except that due to the additional years of operation, decommissioning and the active institutional control period would extend through the year 2268. A berm would be constructed around the perimeter of the site that is 295 hectares (730 acres), 275 hectares (680 acres) of which lies above the 68 panel-equivalents, 12 hectares (30 acres) of which would be for the salt pile, 8 hectares (20 acres) of which would be for surface facilities. DOE would restore the areas occupied by the salt pile and surface facilities and, if necessary, any of the area overlying the disposal panel equivalents, although surface disturbance of this area would be minimal.

3.2.3 Action Alternative 2: Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP

For Action Alternative 2, DOE would treat waste with a thermal process designed to meet the Land Disposal Restrictions (LDR) for TRU mixed waste. The analysis performed for this alternative assumes a 65-percent reduction in the volume of waste due to thermal treatment. WIPP would accept all TRU waste for disposal, which would include the Basic Inventory (including the excess RH-TRU waste) plus the Additional Inventory. For this alternative, the Additional Inventory also includes TRU waste commingled with PCBs. DOE could not dispose of some of the waste types included in the Additional Inventory at WIPP under the current laws and agreements that regulate WIPP.

Three different consolidation and treatment subalternatives are considered under Action Alternative 2. These subalternatives are referred to as Action Alternative 2A, 2B, or 2C and vary only in the location of the treatment sites.

Long Disposal Periods and SEIS-II Results

The action alternatives examined in SEIS-II have waste disposal periods that are much different from the 35-year disposal period of the Proposed Action. Action Alternative 1, all of the Action Alternative 2 subalternatives, and Action Alternative 3 have 160-, 150-, and 190-year disposal periods, respectively. There are three main reasons for these long disposal periods. First, it was assumed that the aboveground configuration of WIPP (principally, the Waste Handling Building and underground access shafts) remains unchanged for all alternatives so waste handling and waste emplacement rates are the same. Second, the waste volumes to be disposed of under the action alternatives would be much greater than the Proposed Action. Third, the final waste form after treatment would affect the volume and heat generation rate of the waste and its ability to meet the WIPP design criteria for thermal loading in the repository.

The large volume of RH-TRU waste in the SEIS-II inventory and the relatively small WIPP throughput rate for RH-TRU waste (8 RH-72B casks per week) are the main reasons for the longer disposal periods for Action Alternatives 1 and 3. Action Alternative 3 waste volumes would also be increased because of the shred and grout treatment. The disposal period for each Action Alternative 2 subalternative would be increased mainly because of the time required to excavate additional underground panels for RH-TRU waste emplacement. The thermally-treated waste form would have greater radioactivity per volume and thus would have to be distributed over a wide area to meet WIPP thermal loading design criteria.

The long disposal periods could be shortened by constructing additional shafts, employing additional shifts, or changing the design criteria for thermal loading.

- Under Action Alternative 2A, CH-TRU waste would be treated at Hanford, Savannah River Site (SRS), Rocky Flats Environmental Technology Site (RFETS), LANL, and Idaho National Engineering Laboratory (INEL)/Argonne National Laboratory-West (ANL-W). RH-TRU waste would be treated at Hanford and ORNL.

- Under Action Alternative 2B, CH-TRU waste would be treated at Hanford, SRS, and INEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL.

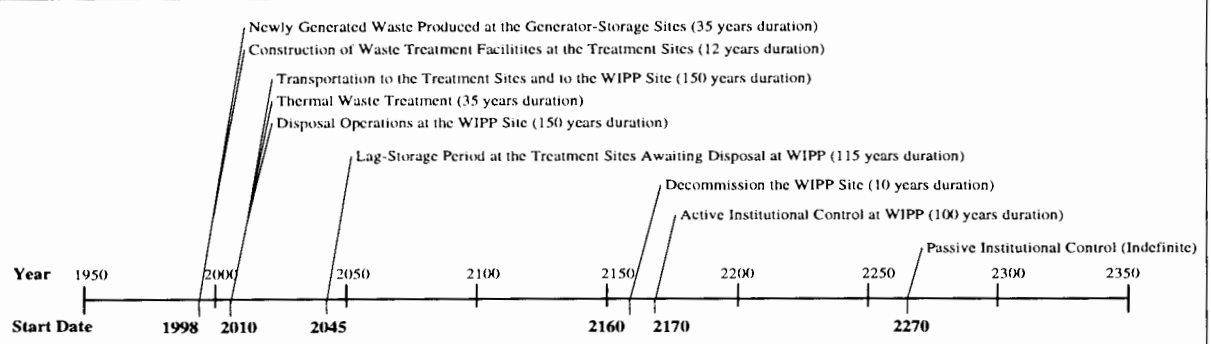
- Under Action Alternative 2C, CH-TRU waste would be treated at WIPP. RH-TRU waste would be treated at Hanford and ORNL.

Table 3-4 presents the CH-TRU waste volumes and Table 3-5 presents the RH-TRU waste volumes for Action Alternative 2A. These tables list the site by volume, pretreatment volume, and post-treatment volume for the Basic Inventory, Additional Inventory, and Total Inventory for each treatment site. Figure 3-3 shows the flow of TRU waste between sites and shipment to WIPP.

Table 3-6 presents the CH-TRU waste volumes and Table 3-7 presents the RH-TRU waste volumes for Action Alternative 2B. Figure 3-4 shows the flow of TRU waste between sites and shipment to WIPP.

Table 3-8 presents the CH-TRU waste volumes and Table 3-9 presents the RH-TRU waste volumes for Action Alternative 2C. Figure 3-5 shows consolidation of TRU waste and shipment to WIPP. DOE would consolidate and treat CH-TRU waste at WIPP and RH-TRU waste at Hanford and ORNL.

A timeline below presents the approximate schedule for disposal activities under the Action Alternative 2 subalternatives. Sites would generate waste for 35 years, beginning in 1998. It would take 12 years to design and construct the treatment facilities for Action Alternatives 2A, 2B, and 2C. The disposal of TRU waste would begin in 2010 and continue for 150 years, ending in 2160. The disposal operations duration is based on the time needed to emplace the total volume of RH-TRU waste, assuming a maximum emplacement rate of 356 cubic meters (12,570 cubic feet) per year, a throughput rate of eight RH-72B canisters per week (DOE 1996c), and an operating time of 50 weeks per year. Decommissioning activities would last for up to 10 years and would be followed by an active institutional control period assumed for analyses to last 100 years, ending in 2270.



Timeline for the Implementation of Action Alternative 2

Table 3-4
CH-TRU Waste Volumes for Action Alternative 2A[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	7,400	4,900	12,000
Idaho National Engineering Laboratory (INEL)[f]	28,000	57,000	85,000	30,000	57,000	87,000	10,000	31,000	41,000
Argonne National Laboratory - West (ANL-W)	1,000	---[g]	1,000	---	---	---	---	---	---
Argonne National Laboratory-East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,000	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	3,800	---	3,800
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	20	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-3.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I
[e] TRU waste commingled with PCBs is included.
[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.

Table 3-5
RH-TRU Waste Volumes for Action Alternative 2A[a]

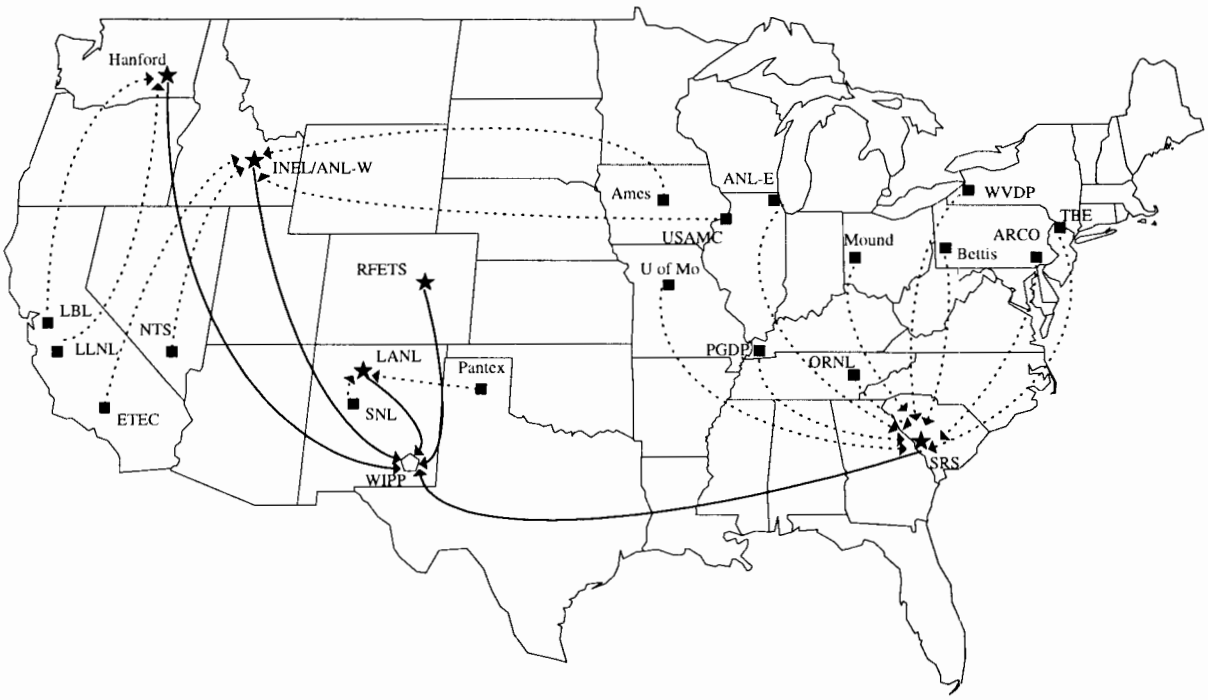
	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
Site[d]	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-3.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

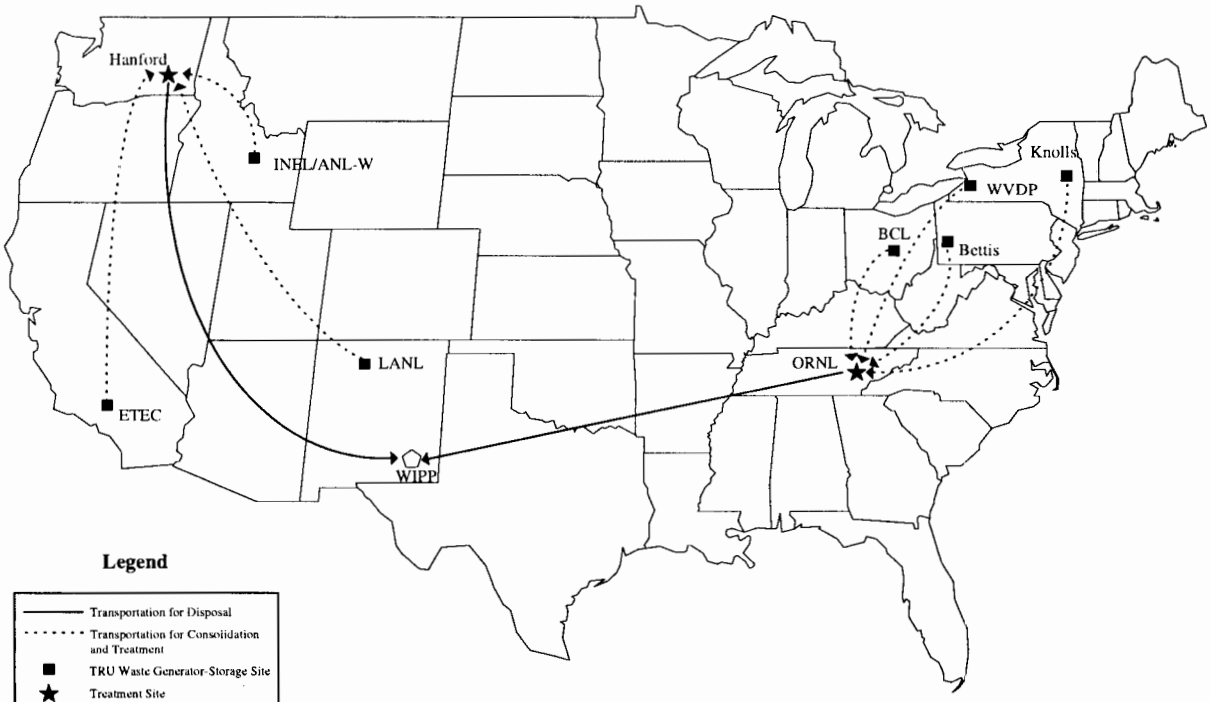
3.2.3.1 Activities at the Generator-Storage Sites

Under this alternative, the generator-storage sites would prepare twice as much waste as under the Proposed Action, and the waste would be treated by a thermal process to meet the RCRA LDRs. Thermal treatment may involve a vitrification process. The process would vaporize organic matter, thereby reducing the total volume of waste. A vitrification process would add silicon-based materials that would result in a glass-like product. The volumes shown in Tables 3-4 through 3-9 reflect the currently stored or projected volumes and any treatment necessary to meet the LDRs. It has been assumed that all waste treatment facilities would be constructed over a period of 12 years and would be ready for operation in the year 2010. Waste treatment would occur over 35 years, through the year 2045, and lag storage of the TRU waste awaiting shipment (under Action Alternatives 2A and 2B) would occur for 115 years, also through the year 2160. Under these alternatives, lag storage would be required due to the rate at which the panels could be excavated.

CH-TRU Waste



RH-TRU Waste



Legend

- Transportation for Disposal
- Transportation for Consolidation and Treatment
- TRU Waste Generator-Storage Site
- Treatment Site
- WIPP

Note: Maps do not show actual transportation routes.

Figure 3-3
Movement of Waste Under Action Alternative 2A
(For complete names of facilities and waste volumes, see Tables 3-4 and 3-5)

Table 3-6
CH-TRU Waste Volumes for Action Alternative 2B[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	28,000	57,000	85,000	62,000	71,000	133,000	22,000	36,000	57,000
Argonne National Laboratory-West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,200	20,000	5,000	1,800	6,900
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-4.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

Table 3-7
RH-TRU Waste Volumes for Action Alternative 2B[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-4.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

3.2.3.2 Transportation Activities

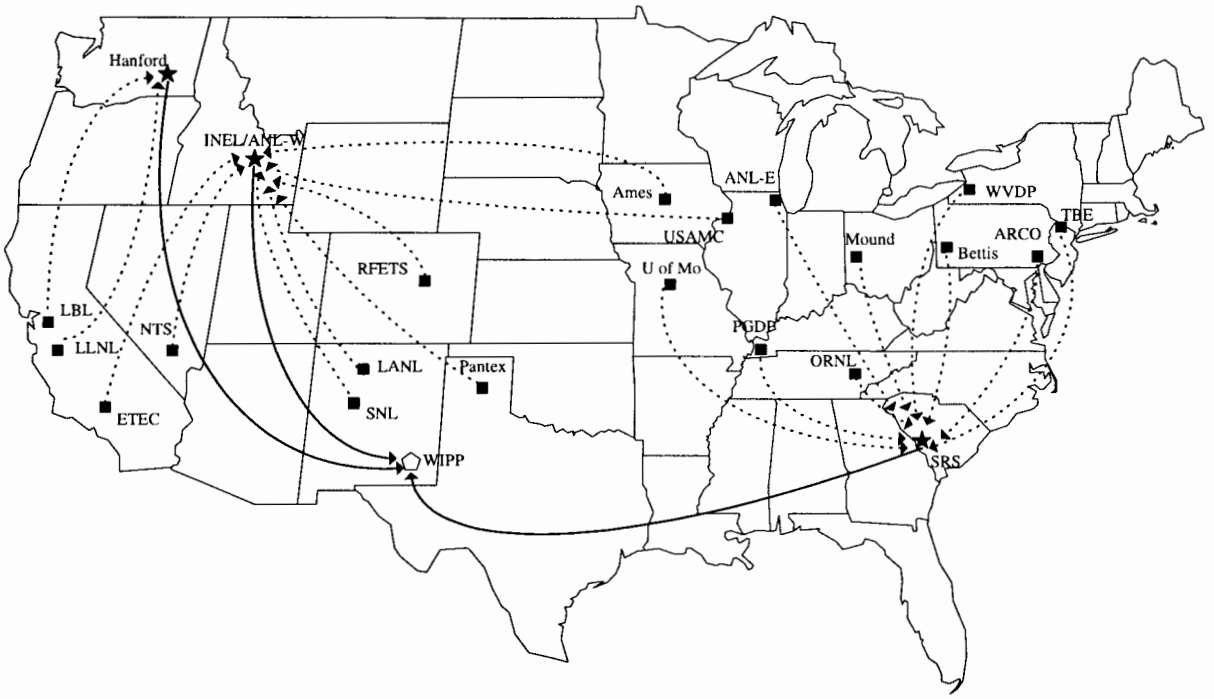
Transportation activities under this alternative would differ from those described for the Proposed Action in the following ways:

- Due to a larger pretreatment waste volume, approximately 9,500 more shipments would be required to transport the Basic and Additional Inventories to WIPP for Action Alternatives 2A and 2B, and 25,000 more shipments for Action Alternative 2C.

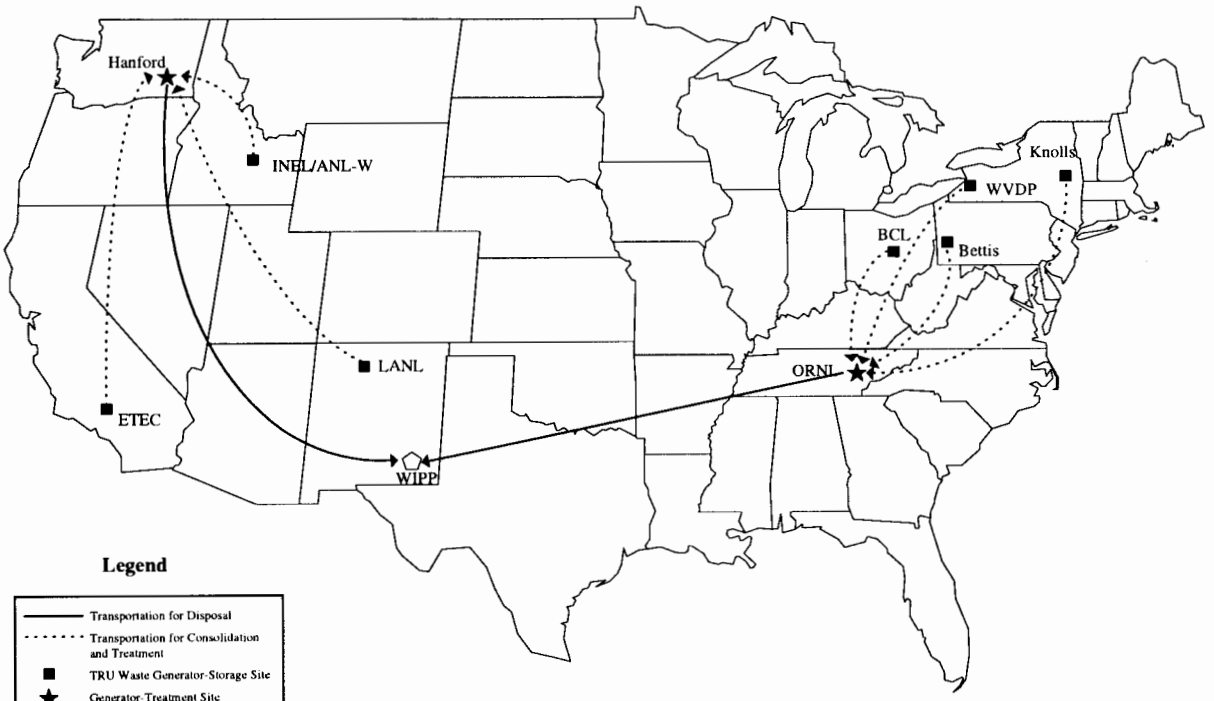
- The period of shipping to consolidation sites and to WIPP would continue for 150 years, through the year 2160 (compared to 35 years under the Proposed Action).

- SEIS-II analyses for this alternative include three transportation scenarios. The first scenario uses only trucks, as described under the Proposed Action. The other two use a mix of maximum commercial rail and truck or maximum dedicated rail and truck, as described in Section 3.2.2.2. WIPP already has a rail spur leading to the facility. Because little storage is permitted at WIPP, all of the transportation scenarios would be spread over the 150-year shipping period.

CH-TRU Waste



RH-TRU Waste



Legend

- Transportation for Disposal
- Transportation for Consolidation and Treatment
- TRU Waste Generator-Storage Site
- Generator-Treatment Site
- WIPP

Note: Maps do not show actual transportation routes.

Figure 3-4
Movement of Waste Under Action Alternative 2B
(For complete names of facilities and waste volumes, see Tables 3-6 and 3-7)

Table 3-8
CH-TRU Waste Volumes for Action Alternative 2C[a]

Site[b]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume (cubic meters)			Post-Treatment Disposal Volume (cubic meters)		
	Basic Inventory	Additional Inventory[c]	Total Inventory	Basic Inventory	Additional Inventory[c]	Total Inventory	Basic Inventory	Additional Inventory[c]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	---[d]	---	---	---	---	---
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	---	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[e]	28,000	57,000	85,000	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory-East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	---	---	---	---	---	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory(ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
WIPP[f]	---	---	---	135,000	139,000	274,000	47,000	60,000	107,000
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Sites in boldface were included in SEIS-I.
[c] TRU waste commingled with PCBs is included.
[d] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.
[e] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[f] TRU waste is consolidated and treated at WIPP.

Table 3-9
RH-TRU Waste Volumes for Action Alternative 2C[a]

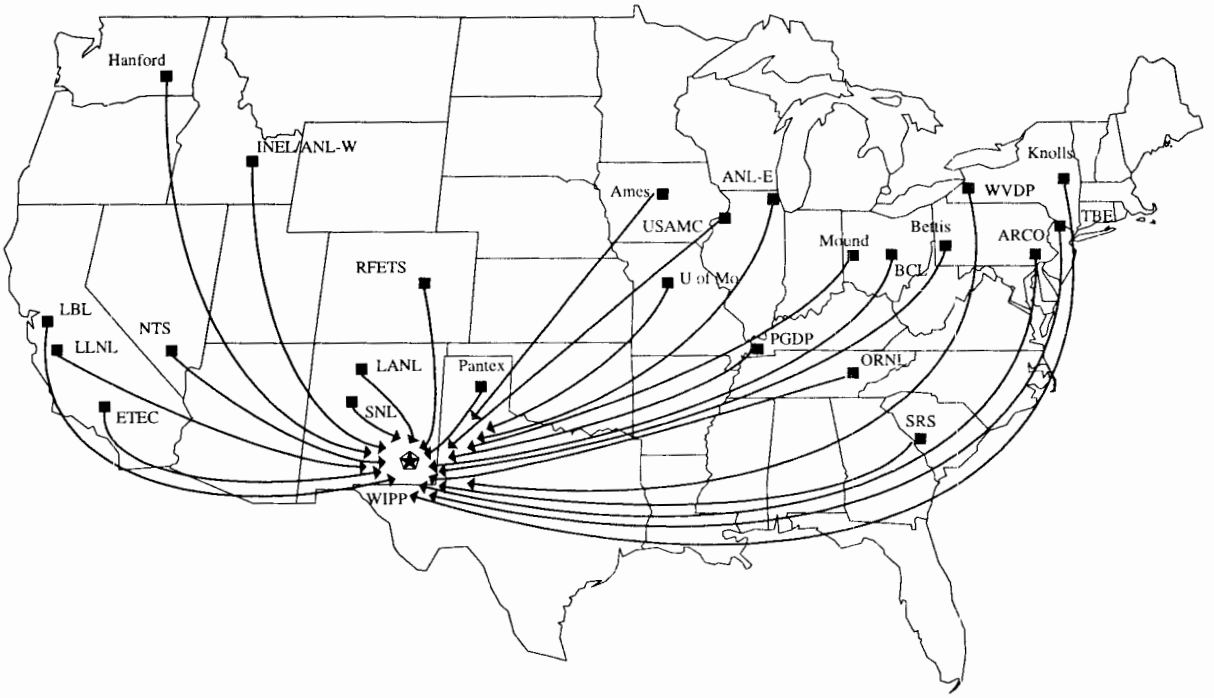
Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-5.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-II.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

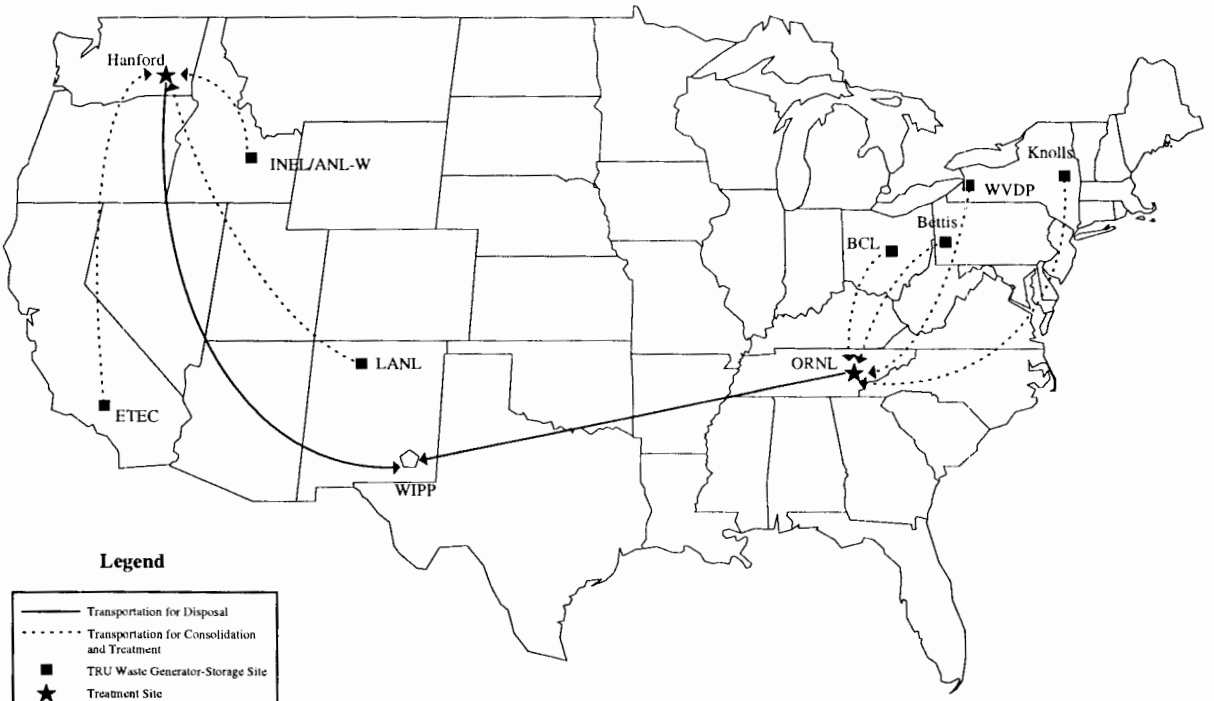
3.2.3.3 Activities at WIPP

Under Action Alternative 2, excavation operations, TRU waste handling operations at the surface, CH-TRU waste emplacement operations, closure, and decommissioning would be similar to the Proposed Action. However, this alternative would extend the operations time frame to as late as the year 2160 even though the overall emplaced waste volume would be smaller than that under all of the other alternatives. As noted above, thermal treatment results in an overall volume reduction of 65 percent. The same quantity of radionuclides would now be present in 35 percent of the original volume, therefore, radionuclide concentration and thermal power generation would increase by a factor of approximately three. Because of the increased thermal power output, CH-TRU waste and RH-TRU waste would be placed in separate panels to meet the WIPP design specifications for thermal power. About 12 panels would be required for CH-TRU waste disposal and about 63 panels would be required for RH-TRU waste disposal, 75 panels total. The time required for excavation of 75 panels, at a rate of two years per panel, is the basis for the 150-year operation period. Any expansion of WIPP capacity would require changes to the LWA and the C&C Agreement.

CH-TRU Waste



RH-TRU Waste



Note: Maps do not show actual transportation routes.

Figure 3-5
Movement of Waste Under Action Alternative 2C
(For complete names of facilities and waste volumes, see Tables 3-8 and 3-9)

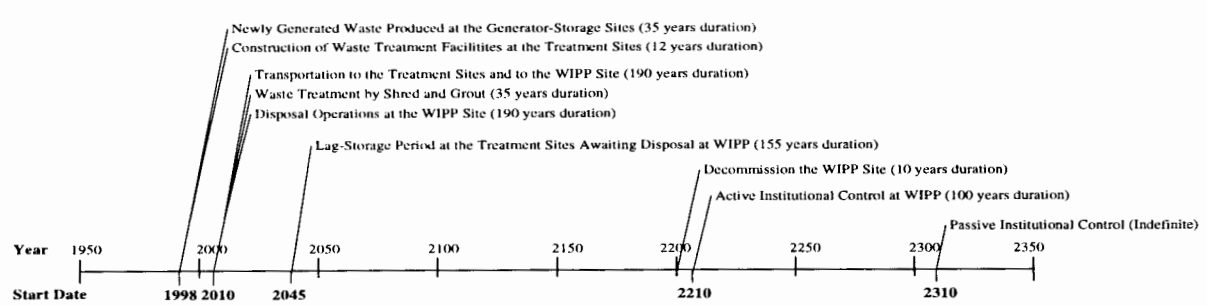
As in the Proposed Action, RH-TRU waste canisters would be emplaced in horizontal boreholes in the walls of the panels. Because of the increased volume of RH-TRU waste, other RH-TRU waste disposal options may be considered, including horizontal boreholes that could accommodate two canisters and vertical boreholes or trenches in the floors of disposal rooms.

Closure and institutional controls would be the same as those for the Proposed Action except that due to the additional years of operation, the decommissioning and active institutional control period would extend through the year 2270. A berm would be constructed around the perimeter of the site, which would include 324 hectares (800 acres), 304 hectares (750 acres) of which lies above the 75 panel equivalents, 12 hectares (30 acres) of which is for the salt pile, and 8 hectares (20 acres) of which is for surface facilities. DOE would restore the areas occupied by the salt pile and surface facilities, and, if necessary, any of the area overlying the disposal panel equivalents, although surface disturbance of this area would be minimal.

3.2.4 Action Alternative 3: Total Inventory (Except PCB-Commingled Waste), Treat by Shred and Grout, Dispose of at WIPP

Action Alternative 3 would involve treating the waste with a shred and grout process. This process would increase the volume by 20 percent. For this alternative, WIPP would accept for disposal all TRU waste, which would include the Basic Inventory plus the Additional Inventory without PCB-commingled waste. DOE could not dispose of some of the Additional Inventory waste types at WIPP under the current laws and agreements that regulate WIPP. Table 3-10 presents the CH-TRU waste volumes and Table 3-11 presents the RH-TRU waste volumes for Action Alternative 3. Figure 3-6 shows the flow of TRU waste between sites and shipment to WIPP. DOE would consolidate and treat CH-TRU waste at Hanford, INEL, LANL, and SRS (RFETS would treat only its own waste). RH-TRU waste would be consolidated and treated at Hanford and ORNL.

A timeline after the tables presents the approximate schedule for disposal activities under Action Alternative 3. Sites would generate waste for 35 years, beginning in 1998. It would take 12 years to design and construct the treatment facilities for Action Alternative 3. The disposal of TRU waste would begin in 2010 and would continue for 190 years, ending in 2200. The disposal operations duration is based on the time needed to emplace the total volume of RH-TRU waste, assuming a maximum emplacement rate of 356 cubic meters (12,570 cubic feet) per year, a throughput rate of eight RH-72B canisters per week (DOE 1996c), and an operating time of 50 weeks per year. Decommissioning activities would last for up to 10 years and would be followed by an active institutional control period assumed for analyses to last 100 years, ending in 2310.



Timeline for the Implementation of Action Alternative 3

Table 3-10
CH-TRU Waste Volumes for Action Alternative 3[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	121,000	70,000	75,000	146,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	25,000	17,000	42,000
Idaho National Engineering Laboratory (INEL)[f]	28,000	57,000	85,000	30,000	57,000	86,000	37,000	68,000	105,000
Argonne National Laboratory - West (ANL-W)	1,000	---[g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,000	20,000	17,000	6,200	23,000
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	19,000	---	19,000
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	---	300	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**138,000**	**273,000**	**135,000**	**138,000**	**273,000**	**168,000**	**166,000**	**334,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-6.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is not included.
[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.

Table 3-11
RH-TRU Waste Volumes for Action Alternative 3[a]

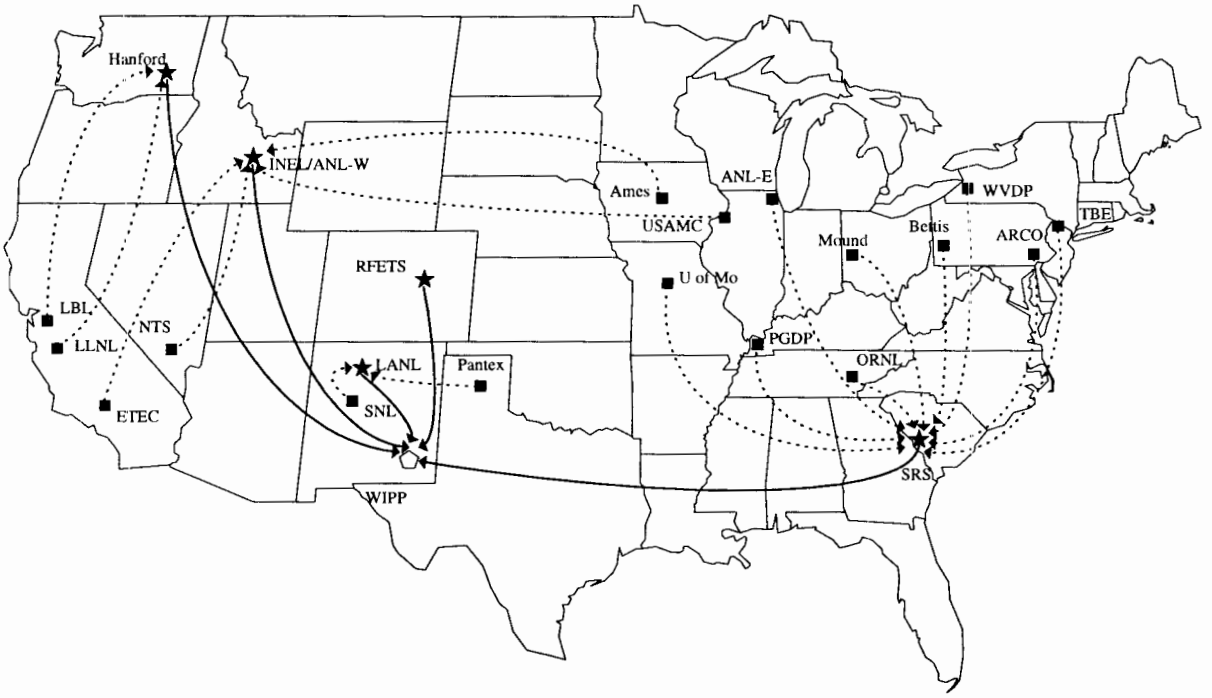
Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	54,000	2,700	57,000
Los Alamos National Laboratory. (LANL)	230	120	350	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	6,300	3,300	10,000
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**60,000**	**6,000**	**66,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-6.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is not included.
[f] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

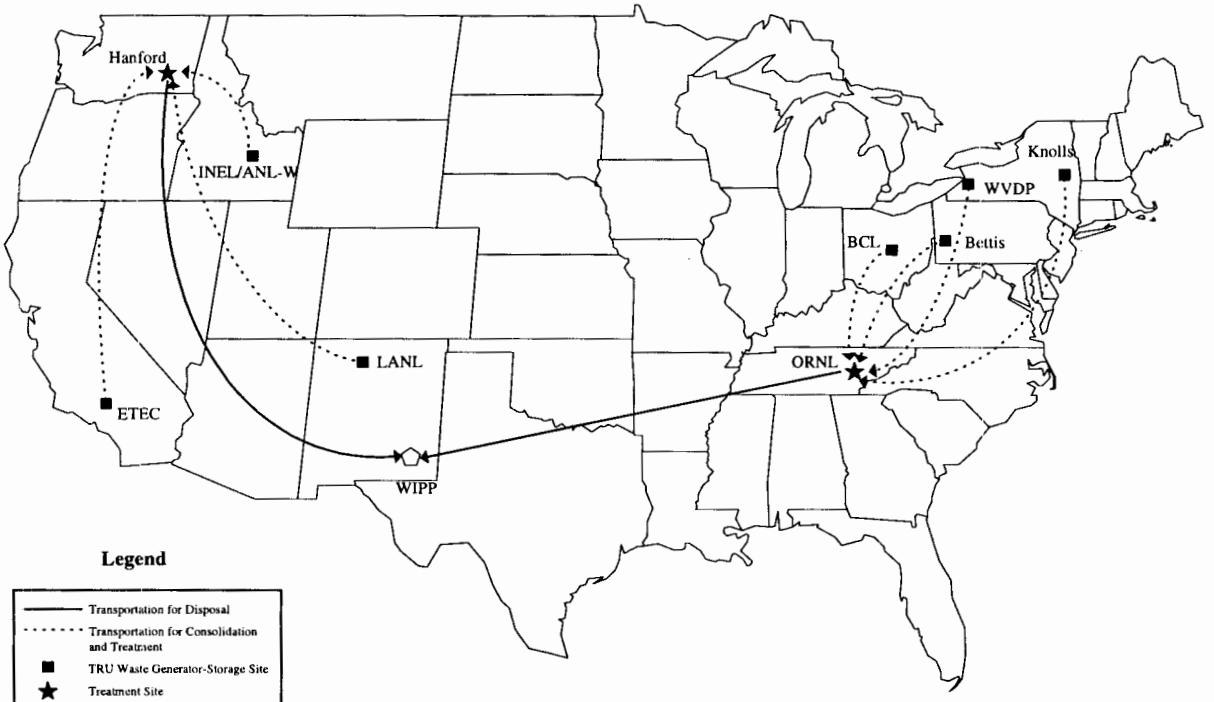
3.2.4.1 Activities at the Generator-Storage Sites

The activities at the generator-storage sites are the same as those described for the Proposed Action, with the exceptions that there would be approximately twice as much waste and that treatment sites would use a shred and grout process to treat the waste. It was assumed that all waste treatment facilities would be constructed over a period of 12 years and would be ready for operation in the year 2010. Waste treatment would occur over 35 years, through the year 2045, and lag storage of the TRU waste awaiting shipment would occur for 155 years, through the year 2200. Lag storage would be necessary due to the rate of emplacement of RH-TRU waste. Engineering details of the shred and grout process that would be used have not been finalized. Nevertheless, such a process would consist of shredding the TRU waste to fragments smaller than some limiting size, perhaps 15 centimeters (6 inches); combining the fragments with a cement-based grout; and placing the mixture in disposal drums. Details on the TRU waste treatment processes are presented in Chapter 2.

CH-TRU Waste



RH-TRU Waste



Legend

- Transportation for Disposal
- Transportation for Consolidation and Treatment
- TRU Waste Generator-Storage Site
- Treatment Site
- WIPP

Note: Maps do not show actual transportation routes.

Figure 3-6
Movement of Waste Under Action Alternative 3
(For complete names of facilities and waste volumes, see Tables 3-10 and 3-11)

3.2.4.2 Transportation Activities

Transportation activities under this alternative would differ from those described for the Proposed Action in the following ways:

- More than twice as many shipments would be required to transport the Basic Inventory and Additional Inventory to WIPP due to a larger pretreatment waste volume and the volume increase resulting from treatment.

- The period of shipping to consolidation sites and to WIPP would occur for 190 years, through the year 2200.

- SEIS-II analyses for this alternative include three transportation scenarios. The first scenario uses truck only, as described under the Proposed Action. The other two use a mix of maximum commercial rail and truck or maximum dedicated rail and truck, as described in Section 3.2.2.2. DOE would not build new rail lines. WIPP already has a rail spur leading to the facility.

3.2.4.3 Activities at WIPP

Under Action Alternative 3, excavation operations, TRU waste handling operations at the surface, CH-TRU waste emplacement operations, closure, and decommissioning would be the same as for the Proposed Action. This alternative would extend the operations time frame to as late as the year 2200 and would accept a larger total volume of TRU waste at WIPP. Seventy-one panels would be excavated to accommodate the additional waste, with 20 panels to accommodate CH-TRU and RH-TRU waste and 51 panels for RH-TRU waste only. Any expansion of WIPP capacity would require changes to the LWA, the C&C Agreement, and various permits to operate WIPP.

As in the Proposed Action, RH-TRU waste canisters would be emplaced in horizontal boreholes in the walls of the panels. Because of the increased volume of RH-TRU waste, other RH-TRU waste disposal options may be considered, including horizontal boreholes that could accommodate two canisters and vertical boreholes or trenches in the floors of disposal rooms.

Closure and institutional controls would be the same as those for the Proposed Action, except that decommissioning and assumed active institutional control period would extend through the year 2310 because of the additional years of operation. A berm would be constructed around the perimeter of the site. This berm would include 307 hectares (760 acres), 287 hectares (710 acres) of which would lie above the 71 panel equivalents, 12 hectares (30 acres) of which would be for the salt pile, and 8 hectares (20 acres) of which would be for surface facilities. DOE would restore the areas occupied by the salt pile and surface facilities, and, if necessary, any of the area overlying the disposal panel equivalents.

3.2.5 No Action Alternative 1: Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP

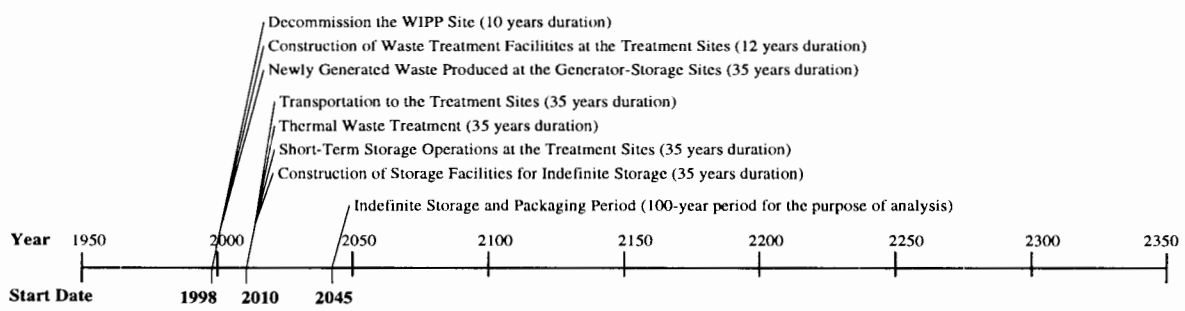
Under No Action Alternative 1, no waste would be shipped to WIPP. DOE would consolidate and thermally treat (assuming a 65-percent reduction in the volume of waste due to thermal treatment) its inventory to meet the LDRs and would manage the treated waste indefinitely in newly engineered and constructed monitored storage facilities at the consolidation sites. The Department would dismantle the existing facilities at WIPP, salvage the equipment for other uses, and close the repository. Agreements and orders between DOE and various states, such as those under the

Federal Facility Compliance Act, could require modification because of the extended time frame for storage.

Two waste treatment subalternatives were assumed for No Action Alternative 1, based on the Draft WM PEIS Regionalized 2 and Regionalized 3 Alternatives. These two subalternatives are referred to as No Action Alternative 1A and 1B, respectively. Table 3-12 presents the CH-TRU waste volumes and Table 3-13 presents the RH-TRU waste volumes for No Action Alternative 1A. Figure 3-7 shows the flow of TRU waste between the sites. DOE would consolidate and treat CH-TRU waste at five sites (Hanford, INEL, LANL, SRS, and RFETS) and RH-TRU waste at two sites (Hanford and ORNL).

Table 3-14 presents the CH-TRU waste volumes and Table 3-15 presents the RH-TRU waste volumes for No Action Alternative 1B. Figure 3-8 shows the flow of TRU waste between sites and shipment to WIPP. DOE would consolidate and treat CH-TRU waste at three sites (Hanford, INEL, and SRS) and would treat RH-TRU waste at two sites (Hanford and ORNL).

A timeline below presents the approximate schedule for No Action Alternatives 1A and 1B. Sites would generate waste for 35 years, beginning in 1998. It would take 12 years to design and construct the treatment facilities for No Action Alternatives 1A and 1B. The waste would be treated for 35 years and stored indefinitely. The treated TRU waste would be placed in and maintained at newly constructed storage facilities. WIPP would be decommissioned immediately. Decommissioning would last 10 years.



Timeline for the Implementation of No Action Alternatives 1A and 1B

3.2.5.1 Activities at the Generator-Storage Sites

Consolidation sites would use a thermal treatment process designed to meet the LDRs. Thermal treatment may involve a vitrification process. This process would destroy organic matter, thereby reducing the total volume of thermally treated waste. A vitrification process would add silica-based materials that would result in a glass-like product. The volumes shown in Tables 3-12 through 3-15 reflect the currently stored and projected volumes and any treatment necessary to meet the LDRs. Waste treatment facilities would be constructed over a period of 12 years and would be ready for operation in the year 2010. The treated waste would be managed for an indefinite period of time at the consolidation sites in newly engineered, monitored storage facilities. Though the Department would investigate designing packages with longer minimal shelf-lives than those currently used, to bound the impacts, it was assumed for the SEIS-II analysis that TRU waste

Table 3-12
CH-TRU Waste Volumes for No Action Alternative 1A[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	7,400	4,900	12,000
Idaho National Engineering Laboratory (INEL)[f]	28,000	57,000	85,000	30,000	57,000	87,000	10,000	31,000	41,000
Argonne National Laboratory - West (ANL-W)	1,000	---[g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,200	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	3,800	---	3,800
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Material Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-7.
[c] Post-treatment volumes have been adjusted to meet safe packaging criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.

Table 3-13
RH-TRU Waste Volumes for No Action Alternative 1A[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-7.
[c] Post-treatment volumes have been adjusted to meet safe packaging criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

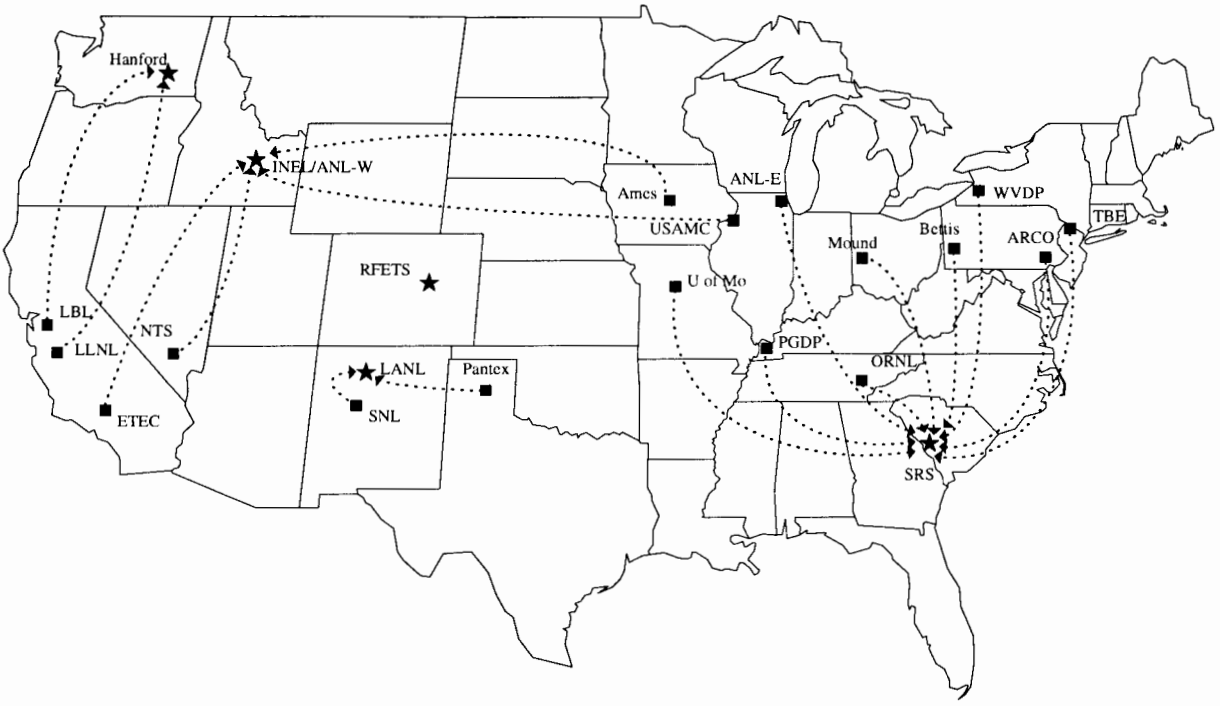
packaging would be performed every 20 years. Currently used drums and waste boxes have a relatively short design life and would degrade over time due to corrosion. It was further assumed, for purposes of analysis, that the storage facilities themselves would be refurbished or replaced at least every 50 years, although the Department may attempt to design facilities with a longer lifetime under this alternative.

3.2.5.2 Transportation Activities

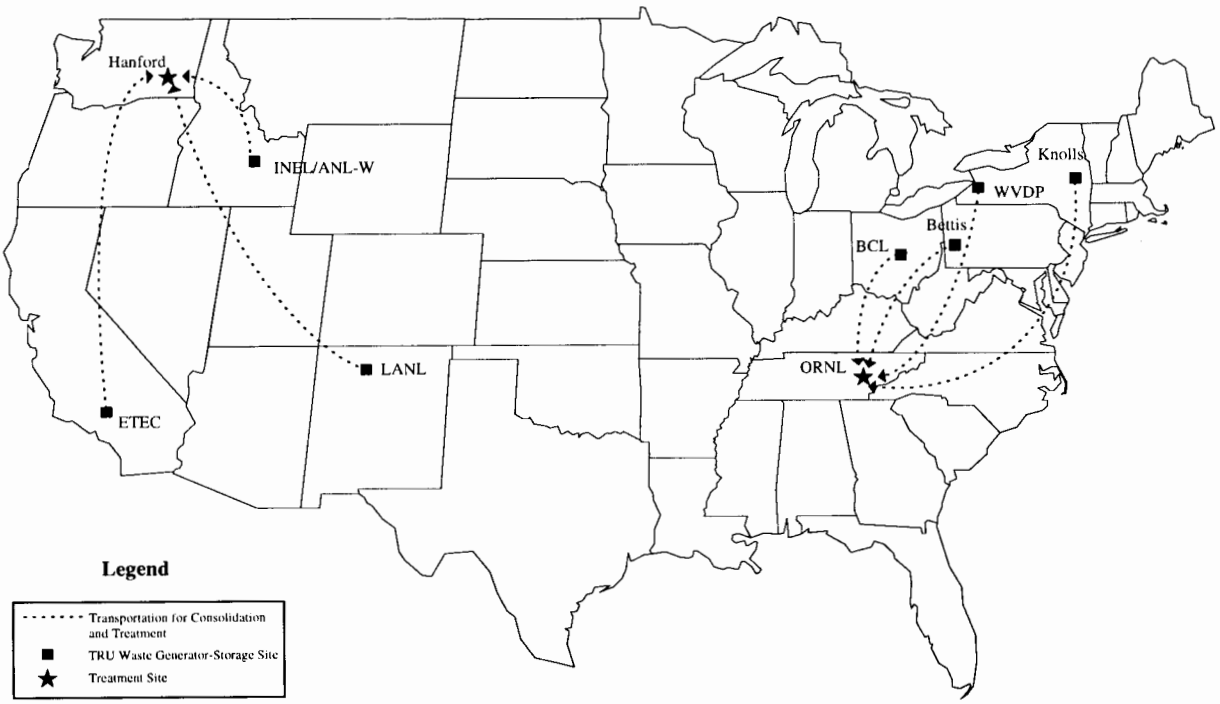
Transportation activities under this alternative would differ from those described for the Proposed Action in the following ways:

- No waste would be shipped to WIPP.
- The period of shipping to consolidation sites would begin in the year 2010.
- SEIS-II analyses for this alternative include three transportation scenarios. The first scenario uses truck only, as described under the Proposed Action. The other two scenarios use a mix of maximum commercial rail and truck or maximum dedicated rail and truck, as described in Section 3.2.2.2.

CH-TRU Waste



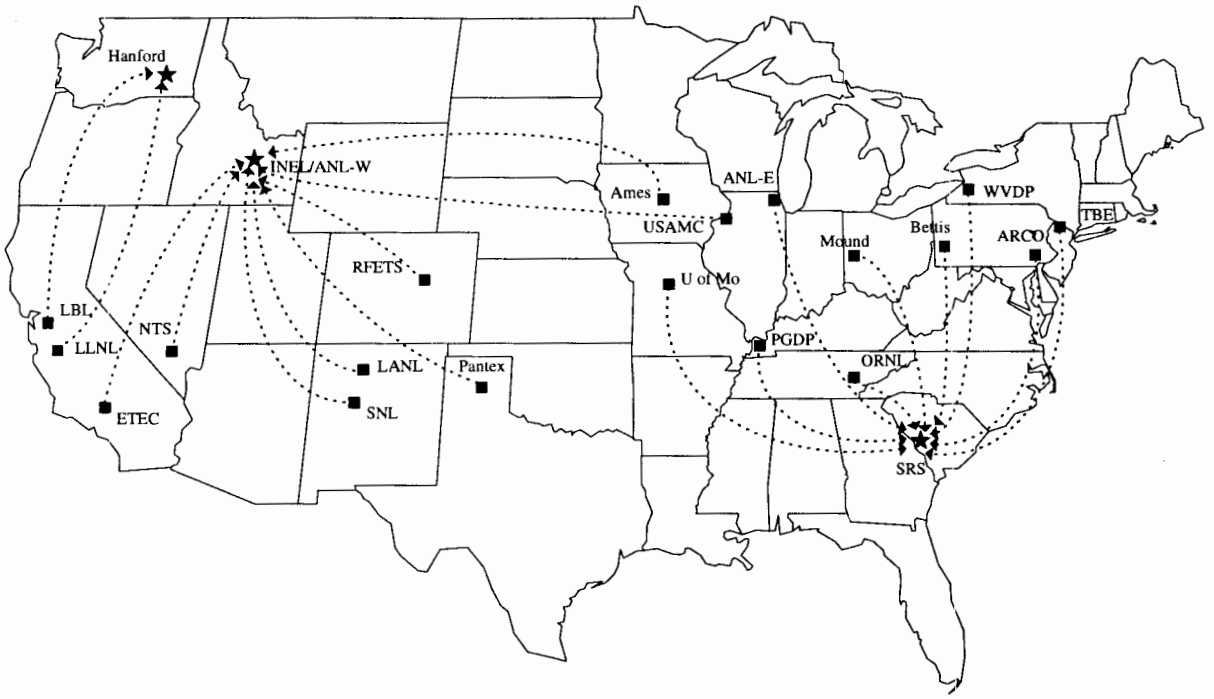
RH-TRU Waste



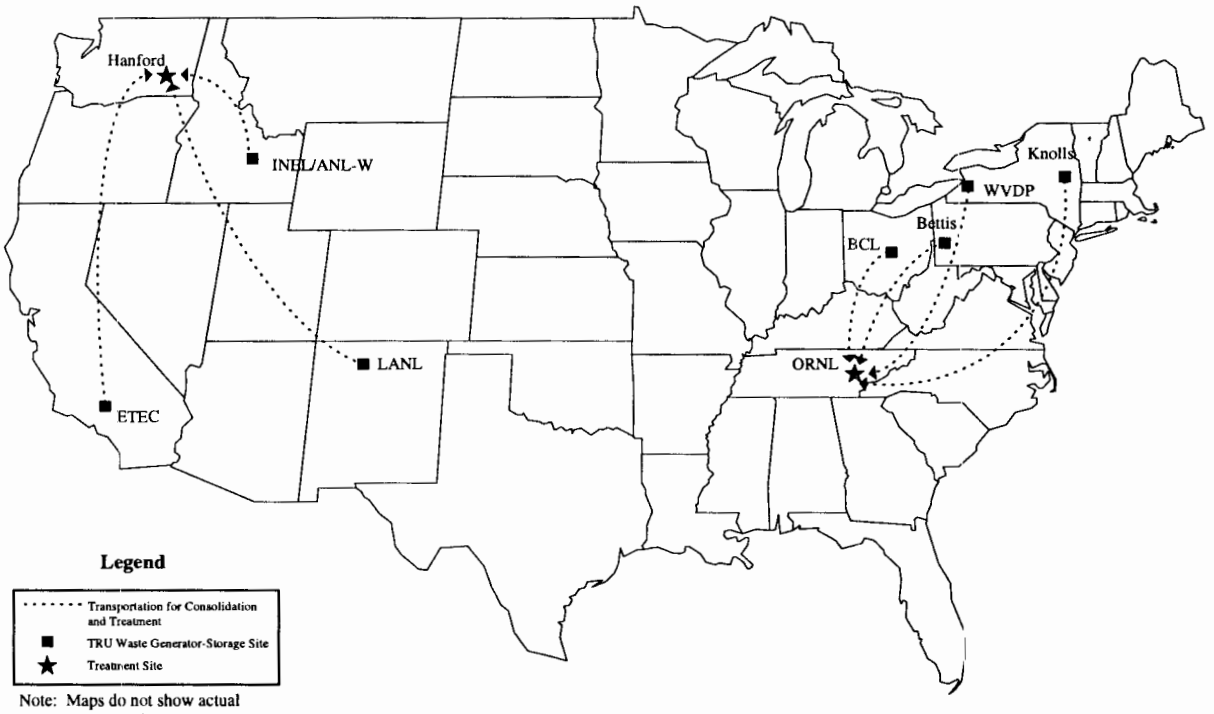
Note: Maps do not show actual transportation routes.

Figure 3-7
Movement of Waste Under No Action Alternative 1A
(For complete names of facilities and waste volumes, see Tables 3-12 and 3-13)

CH-TRU Waste



RH-TRU Waste



Note: Maps do not show actual transportation routes.

Figure 3-8
Movement of Waste Under No Action Alternative 1B
(For complete names of facilities and waste volumes, see Tables 3-14 and 3-15)

Table 3-14
CH-TRU Waste Volumes for No Action Alternative 1B[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	28,000	57,000	85,000	62,000	71,000	133,000	22,000	36,000	57,000
Argonne National Laboratory - West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,200	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.

[b] Volumes include consolidation of waste as indicated on Figure 3-8.

[c] Post-treatment volumes have been adjusted to meet safe packaging criteria.

[d] Sites in boldface were included in SEIS-I.

[e] TRU waste commingled with PCBs is included.

[f] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.

[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

Table 3-15
RH-TRU Waste Volumes for No Action Alternative 1B[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,600**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-8.
[c] Post-treatment volumes have been adjusted to meet safe packaging criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste. Some sites with dashes would continue to generate waste through 2033, but this newly generated would then be consolidated at the 10 consolidation sites.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

3.2.5.3 Activities at WIPP

There would be no disposal activities at WIPP; the Department would terminate its WIPP mission. DOE would fill the shafts with salt from the storage pile and then seal the excavation. The aboveground site would be restored and perhaps returned to the U.S. Bureau of Land Management (BLM). DOE would salvage all usable equipment and dismantle and remove the surface facilities.

3.2.6 No Action Alternative 2: Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP

Activities associated with No Action Alternative 2 are discussed below. There would be no treatment of stored waste, although newly generated waste would be treated to the requirements of WAC for safe storage. There would be no transportation of any of the waste from the generator-storage sites, unless future agreements require such movement.

3.2.6.1 Activities at the Generator-Storage Sites

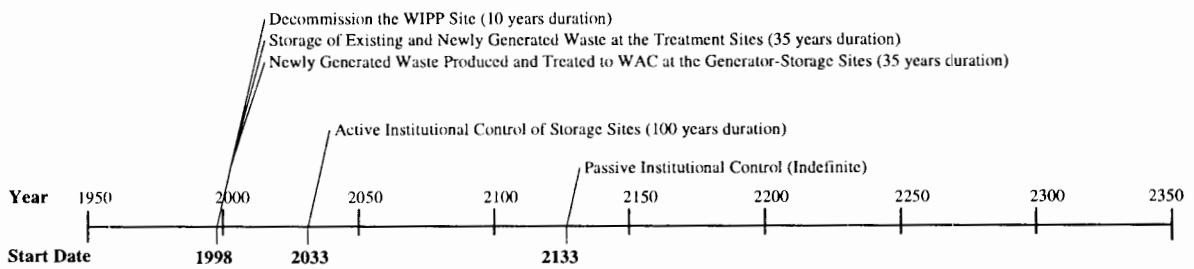
Under No Action Alternative 2, no waste would be shipped to WIPP. Current TRU waste management practices would continue at all sites, except where DOE has entered into agreements to have waste removed from small quantity sites to facilitate safe long-term storage. In such cases, shipment of TRU waste from a small quantity site to a consolidation site would be by truck. Newly generated TRU waste would be treated to WAC for safe storage. Existing TRU waste in storage would not be treated but would continue to be managed under current practices. Newly generated waste would constitute about 73,000 cubic meters (2,600,000 cubic feet) of the 143,000 cubic meters (5,000,000 cubic feet) of CH-TRU waste and 32,000 cubic meters (1,100,000 cubic feet) of the 50,000 cubic meters (1,800,000 cubic feet) of RH-TRU waste in the Basic Inventory. Table 3-16 presents TRU waste volumes for No Action Alternative 2.

Table 3-16
TRU Waste Volumes for No Action Alternative 2[a]

Site[b]	Site Volume Through 2033 (cubic meters)		Existing Stored Volume (cubic meters)		Newly Generated Post-Treatment Volume (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	57,490	29,420	12,300	200	45,190	29,200
Los Alamos National Laboratory (LANL)	21,000	230	11,050	90	9,980	130
Idaho National Engineering Laboratory (INEL)[c]	28,150	220	28,150	220	---	---
Argonne National Laboratory - West (ANL-W)	1,010	1,740	7	20	1,005	1,720
Argonne National Laboratory - East (ANL-E)	200	---[d]	25	---	180	---
Savannah River Site (SRS)	12,070	---	2,880	---	9,180	---
Rocky Flats Environmental Technology Site (RFETS)	10,860	---	4,890	---	5,970	---
Oak Ridge National Laboratory (ORNL)	1,670	3,080	1,320	2,470	350	600
Lawrence Livermore National Laboratory (LLNL)	1,200	---	230	---	960	---
Nevada Test Site (NTS)	630	---	620	---	10	---
Mound Plant (Mound)	300	---	300	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	9	---	---	170	9
Sandia National Laboratories - Albuquerque (SNL)	17	---	7	---	10	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	---	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---
Energy Technology Engineering Center (ETEC)	2	7	2	6	---	1
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---
Pantex Plant (Pantex)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---
Battelle Columbus Laboratories (BCL)	---	580	---	590	---	---
Total	**135,000**	**35,000**	**62,000**	**3,600**	**73,000**	**32,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Sites in boldface were included in SEIS-I.
[c] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[d] Dashes indicate no waste.

A timeline below presents the approximate schedule under No Action Alternative 2. Sites would continue to generate waste for 35 years and would store the waste. WIPP would be decommissioned beginning immediately.



Timeline for the Implementation of No Action Alternative 2

3.2.6.2 Transportation Activities

The generator-storage sites would only ship waste to the consolidation sites if it were to facilitate safe storage or requirements of future agreements. No waste would be shipped to WIPP.

3.2.6.3 Activities at WIPP

There would be no disposal activities at WIPP; the Department would terminate its WIPP mission. DOE would fill the shafts with salt and then seal the excavation. DOE would restore the aboveground site and perhaps return it to the BLM. DOE would salvage all usable equipment and dismantle and remove the surface facilities according to the WIPP Land Management Plan (DOE 1993).

3.3 ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL

SEIS-II does not include detailed analyses of several alternatives discussed during the scoping process. These alternatives were not analyzed in detail because — depending on the alternative — they are not technically viable, would not adequately or economically meet DOE's need to safely dispose of TRU waste in a timely manner, involve additional environmental and policy concerns that would need to be accommodated, or are otherwise unreasonable in the present context. The following alternatives are not analyzed in detail.

Transmutation. An accelerator or a reactor could possibly be used to transmutate long-lived radionuclides into short-lived or stable nuclides; however, the transmutation process has not been demonstrated for TRU waste. Also, transmutation is a technology that has not yet been proven for production-size facilities. The transmutation process, as well as reactor operations, would result in fission products that would have to be disposed of as radioactive waste by some other method. This alternative was considered and rejected for the same reasons in the 1980 *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980).

Coprocess with high level waste and vitrify[1]. TRU and high level waste could be combined and mixed with molten glass. This vitrification would produce highly radioactive glass "logs" that

[1] Vitrification of TRU waste not mixed with high-level waste is considered in SEIS-II.

would have to be stored in interim storage and eventually buried in a geologic repository (NAS 1994). While the *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement* (DOE 1996b) considered this process to be a reasonable alternative for analysis, the relatively large volume of TRU waste (as compared to the volume of fissile material) would produce much more waste than the currently planned high-level waste repository could dispose of. This alternative would further delay TRU waste disposal until such a time as sufficient high-level waste repository space was available. In addition, transportation and safety concerns associated with high level waste would need to be addressed.

Disposal in space. This alternative was considered and rejected in the FEIS. The disposal of TRU waste in a low earth orbit would not be sufficient because material in such an orbit would fall back to earth over a time span that is short as compared to the necessary disposal time and decay time of the TRU waste. Therefore, the waste would have to be launched into an orbit around the sun that is unlikely to encounter the earth or be put on a path to fall into the sun or escape the solar system entirely. The type and number of rockets needed for this type of launch would be very expensive, and the rockets would have to be very reliable. Even with reliable rockets, the possibility of a rocket failure exists, and such a failure could result in the waste reentering from space (NAS 1994).

Underground detonation. Such detonations would produce a large amount of hazardous fission products. The waste form resulting from a detonation would be somewhat unpredictable and it would be embedded in an underground location not selected for, or designed as, a long-term repository (NAS 1994). Because of the volume of waste to be disposed of, a large number of detonations would be required. Also, the geologic environment around the detonation points would be greatly disturbed. The manufacture of the explosive devices used in the detonations would generate more waste. This alternative would present additional environmental and policy concerns that would have to be addressed.

Subseabed disposal. This alternative was considered and rejected in the FEIS. Subseabed disposal of TRU waste would involve implanting canisters of TRU waste tens of meters into deep ocean sediments by free-fall penetration or other techniques (DOE 1980). In addition, subseabed disposal is prohibited by international treaties, and further development would be required. The U.S. program studying subseabed disposal was canceled in 1986, and no other country is currently pursuing such research.

Deep borehole disposal. This alternative involves drilling or sinking very deep boreholes or shafts (3,000-meters [9,840-feet] or more) and placing TRU waste canisters into these holes. This method relies on the surrounding rock to contain the waste and on the great depths to delay the release and reentry of radioactive material into the biosphere. This disposal method was reviewed in the FEIS (DOE 1980) and was ruled out because of substantial technical challenges in characterizing the geological conditions at the depth of interest, severe engineering problems in excavating deep holes and emplacing waste canisters, and the large number of boreholes (800 to 1,300) estimated to be required. Deep borehole disposal is currently being evaluated as a candidate technology for possible disposal of surplus fissile materials (DOE 1996b). However, the technology may be more practicable for disposal of surplus fissile materials than for disposal of TRU waste because the volume of fissile materials potentially requiring disposal is many times smaller than the volume of TRU waste. Also, because many years of investigation and development would be needed before this method might be available for the disposal of TRU waste, selection of this technology would considerably delay the disposal of TRU waste.

Greater confinement (shallow borehole). This disposal method involves burial of waste in containers engineered to provide multiple barriers in shallow boreholes at a depth of about

100 feet. At many DOE sites, waste buried at this depth would likely interact with groundwater and could eventually pose an environmental and human health hazard. Greater confinement disposal is being used for some waste types at the NTS, which has a deep water table, and greater confinement disposal of small quantities of TRU waste in this manner might be feasible. The degree of isolation that could be provided by greater confinement disposal over the 10,000-year-plus period WIPP would be expected to isolate waste is unknown, but this relatively shallow burial method offers no apparent advantage over disposal at WIPP. The need to evaluate the ability of any anticipated greater confinement disposal site to isolate waste would further delay disposal of TRU waste by several years. For the volume of waste that DOE proposes to dispose of in WIPP, greater confinement disposal would be a less cost-effective method of disposal.

Geologic repositories at sites other than WIPP. Three general classes of geologic media have been considered in the past for the disposal of radioactive waste (DOE 1980). These geologic media are salt, igneous rocks (granite, basalt, and tuff), and argillaceous rocks (shale). Salt is a favorable disposal media because of its thermal and physical properties and because its very survival for hundreds of millions of years has demonstrated its isolation from circulating groundwater and the stability of the geologic formations in which it is located (DOE 1980).

Alternative Engineered Barriers. Regulations within 40 CFR Part 194 suggest that alternative engineered barriers, including some not specifically examined here (e.g., supercompaction, improved waste canisters, grout and bentonite backfill) should be considered. The Department examined these as alternatives and determined based on the evaluation conducted in the *Engineered Alternatives Cost/Benefit Study Final Report* (DOE 1995c) that they were less effective than the engineered barriers examined in SEIS-II.

Other Suggestions. Zircon technology and changing the state of atoms to "supercold" in order to slow down radionuclide activity were technologies suggested for TRU waste treatment methods during the public scoping process. None of these technologies are currently technically or economically feasible, and their use as treatment or disposal alternatives would require additional research.

3.4 COMPARISON OF THE PROPOSED ACTION AND ALTERNATIVES

Table 3-17 gives a tabular comparison of the major features of the Proposed Action and the alternatives. This table is meant to help the reader understand the differences and similarities among the different courses of action described in SEIS-II. Figures 3-9 and 3-10 provide graphical comparisons of the CH-TRU and RH-TRU post-treatment waste volumes that would be disposed of according to alternative.

Over the life of campaign, routine operation under the Proposed Action could result in an estimated six worker fatalities at waste treatment sites and three worker fatalities at WIPP. Truck transportation under the Proposed Action could result in an estimated additional nine deaths among members of the public and crew. Although highly unlikely, the most severe accident, a severe truck accident with a maximum radionuclide inventory having a frequency of less than 7.5×10^{-7}, could result in an additional 16 deaths. The waste disposed of at WIPP under the Proposed Action would be isolated from the environment for more than 10,000 years. However, the Proposed Action would leave the excess RH-TRU waste (from the Basic Inventory) and about half of the total TRU waste volume (from the Total Inventory) in storage, and subject to release if DOE were to lose institutional control of the sites where it was stored. Health impacts due to any released waste at the storage sites could vary depending on the population density in the vicinity at the time

SEIS-II AND THE DRAFT WM PEIS ALTERNATIVES

Each SEIS-II alternative is similar to an alternative in the Draft WM PEIS in the way consolidation and treatment of waste are assumed. Below is a list of the similarities.

The SEIS-II Proposed Action is similar to the Draft WM PEIS Decentralized Alternative. In both alternatives, TRU waste would be treated to WAC at the facility where it currently is stored or would be generated. The waste would then be consolidated at the 10 facilities with the largest volume of waste to await disposal at WIPP. Those 10 sites are Hanford, LANL, INEL, ANL-East, SRS, RFETS, ORNL, Lawrence Livermore National Laboratory (LLNL), NTS, and the Mound Plant (Mound). The SEIS-II inventory includes small quantities of TRU waste from several sites that were not considered for the Draft WM PEIS. Waste from these sites would be consolidated at the closest site with larger volumes, if necessary.

The SEIS-II Action Alternative 1 also is similar to the Draft WM PEIS Decentralized Alternative. In both, TRU waste would be treated to WAC at the facility where it currently is stored or would be generated. The waste would then be consolidated at the same 10 facilities as for the Proposed Action. (The major difference between the SEIS-II Proposed Action and the SEIS-II Action Alternative 1 is the amount of waste to be disposed of.)

The three SEIS-II Action Alternative 2 subalternatives are similar to the Draft WM PEIS Regionalized 2, Regionalized 3, and Centralized Alternatives. In each, the TRU waste would be consolidated at treatment sites where it would be treated by a thermal process to meet the RCRA LDRs. The three different consolidation and treatment options considered under Action Alternative 2 are:

- **Action Alternative 2A:** CH-TRU waste would be treated at Hanford, SRS, RFETS, LANL, and INEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL. This option is similar to the Draft WM PEIS Regionalized 2 Alternative.

- **Action Alternative 2B:** CH-TRU waste would be treated at Hanford, SRS, and INEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL. This option is similar to the Draft WM PEIS Regionalized 3 Alternative.

- **Action Alternative 2C:** CH-TRU waste would be treated at WIPP. RH-TRU waste would be treated at Hanford and ORNL. This option is similar to the Draft WM PEIS Centralized Alternative.

The SEIS-II Action Alternative 3 is similar to the Draft WM PEIS Regionalized 1 Alternative. For both alternatives, TRU waste would be consolidated at regional sites throughout the country and treated by a shred and grout process before shipping the TRU waste to WIPP. CH-TRU waste would be treated at Hanford, LANL, RFETS, SRS, and INEL/ANL-W. RH-TRU waste would be treated at Hanford and ORNL.

The two SEIS-II No Action Alternative 1 subalternatives are similar to the Draft WM PEIS Regionalized 2 and Regionalized 3 Alternatives. The waste would be treated at the same sites described above for the SEIS-II Action Alternatives 2A, 2B, and 2C. SEIS-II No Action Alternative 1A is similar to the Draft WM PEIS Regionalized 2 Alternative; SEIS-II No Action Alternative 1B is similar to the Draft WM PEIS Regionalized 3 Alternative.

The SEIS-II No Action Alternative 2 is similar to the Draft WM PEIS No Action Alternative. In both, the waste is left untreated (except for newly generated waste) and is stored at the facilities where it is currently located or would be generated.

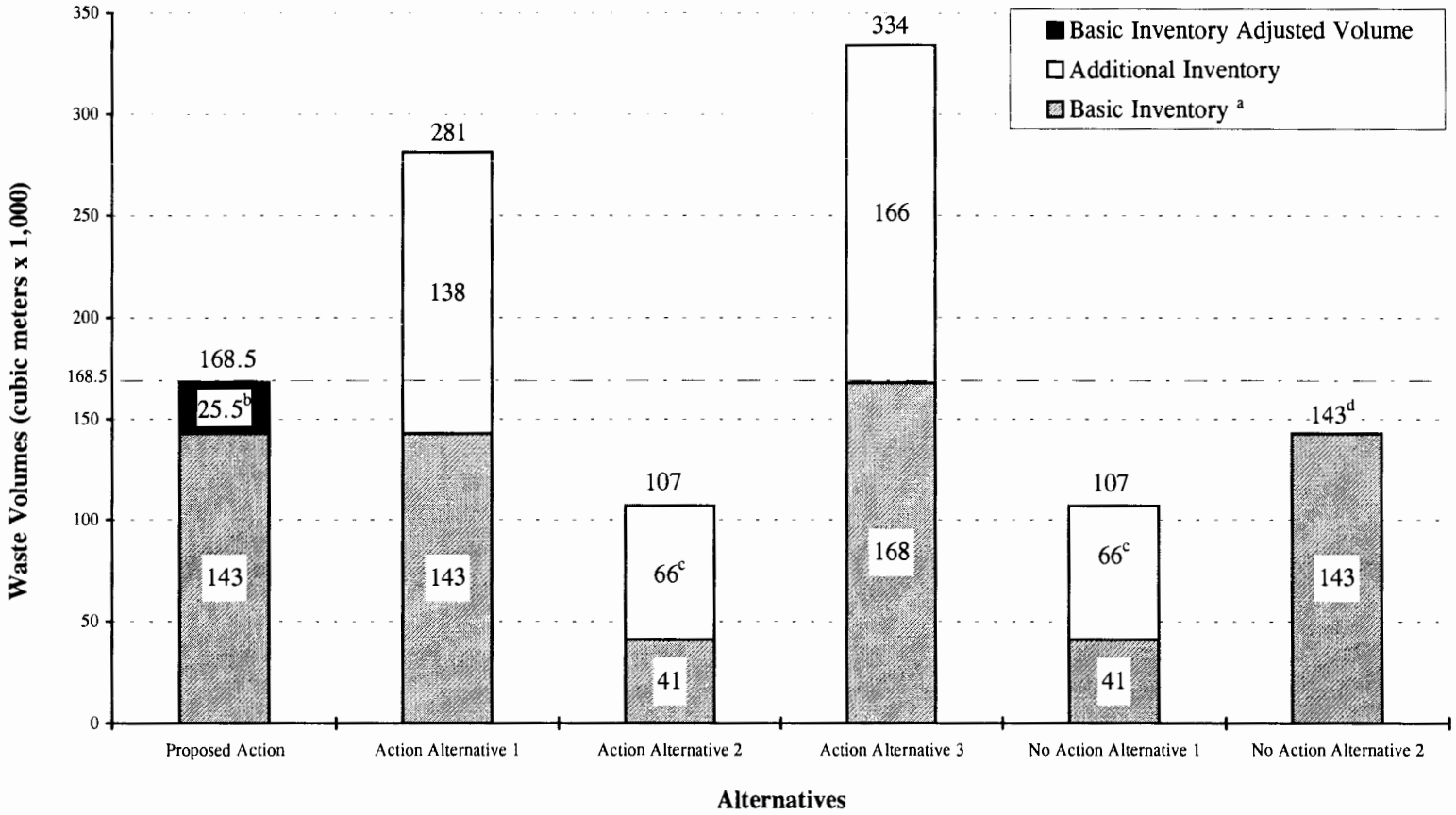
Table 3-17
Summary of WIPP SEIS-II Alternatives

Comparison Parameters	*Proposed Action:* Basic Inventory, Treat to WAC, Dispose of at WIPP	*Action Alternative 1:* Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP	*Action Alternative 2:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP	*Action Alternative 3:* Total Inventory (Except PCB-Commingled TRU Waste), Treat by Shred and Grout, Dispose of at WIPP	*No Action Alternative 1:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP	*No Action Alternative 2:* Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP [a]
Waste Type	Defense-related, post-1970 TRU waste in retrievable storage and newly generated through the year 2033 (Basic Inventory).	Basic Inventory plus other DOE-owned or controlled waste including non-defense, commercial, previously disposed of waste, and excluding PCB-commingled waste (Additional Inventory).	Basic Inventory plus Additional Inventory (including PCB-commingled waste).	Basic Inventory plus Additional Inventory (excluding PCB-commingled waste).	Basic Inventory plus Additional Inventory (including PCB-commingled waste).	Same as Proposed Action.
Post-Treatment Volume[b] to be Disposed of at WIPP, or Stored	CH-TRU: 168,500 m^3 (5,950,000 ft^3) RH-TRU: 7,080 m^3 (250,000 ft^3) Excess Waste RH-TRU 43,000 m^3 (1,500,000 ft^3)	CH-TRU: 281,000 m^3 (9,900,000 ft^3) RH-TRU: 55,000 m^3 (2,000,000 ft^3)	CH-TRU: 107,000 m^3 (3,800,000 ft^3) RH-TRU: 19,000 m^3 (690,000 ft^3)	CH-TRU: 334,000 m^3 (11,800,000 ft^3) RH-TRU: 66,000 m^3 (2,300,000 ft^3)	CH-TRU: 107,000 m^3 (3,800,000 ft^3) RH-TRU: 19,000 m^3 (690,000 ft^3)	CH-TRU: 135,000 m^3 (4,800,000 ft^3) RH-TRU: 35,000 m^3 (1,200,000 ft^3)
Waste Consolidation and Treatment Locations	20 sites total - WAC treatment of CH-TRU at the largest sites and store at 10 largest sites[c]. Ship to WIPP. - WAC treatment of RH-TRU at Hanford, INEL/ANL-W, ORNL, and LANL. Ship to WIPP.	24 sites total - Same as Proposed Action except two other sites (LBL, WVDP) consolidate and treat CH-TRU at Mound and Hanford.	24 sites total Action Alternative 2A - LDR treatment of CH-TRU at Hanford, INEL, LANL, SRS, and RFETS. - LDR treatment of RH-TRU at Hanford and ORNL. Action Alternative 2B - LDR treatment of CH-TRU at Hanford, INEL, and SRS. - LDR treatment of RH-TRU at Hanford and ORNL. Action Alternative 2C - LDR treatment of CH-TRU at WIPP. - LDR treatment of RH-TRU at Hanford and ORNL.	24 sites total - Shred and grout treatment of CH-TRU at Hanford, INEL, LANL, SRS, and RFETS. - Shred and grout RH-TRU at Hanford and ORNL.	24 sites total No Action Alternative 1A - LDR treatment of CH-TRU at Hanford, INEL, LANL, SRS, and RFETS. - LDR treatment of RH-TRU at Hanford and ORNL. No Action Alternative 1B - LDR treatment of CH-TRU at Hanford, INEL, and SRS. - LDR treatment of RH-TRU at Hanford and ORNL.	Minimal consolidation to ensure safe storage; however, no sites would ship to WIPP.
Waste Treatment	Treat to meet WAC.	Treat to meet WAC.	Thermal treatment to meet the LDRs (including PCB-commingled waste).	Treatment by shred and grout.	Thermal treatment to meet the LDRs (including PCB-commingled waste). Package every 20 years indefinitely.	Newly generated waste treated to WAC.

Table 3-17
Summary of WIPP SEIS-II Alternatives—Continued

Comparison Parameters	*Proposed Action:* Basic Inventory, Treat to WAC, Dispose of at WIPP	*Action Alternative 1:* Total Inventory (Except PCB-Commingled TRU Waste), Treat to WAC, Dispose of at WIPP	*Action Alternative 2:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Dispose of at WIPP	*Action Alternative 3:* Total Inventory (Except PCB-Commingled TRU Waste), Treat by Shred and Grout, Dispose of at WIPP	*No Action Alternative 1:* Total Inventory (Including PCB-Commingled TRU Waste), Treat Thermally to Meet LDRs, Store Indefinitely, Dismantle WIPP	*No Action Alternative 2:* Basic Inventory, Treat Newly Generated TRU Waste to WAC, Store at Generator Sites, Dismantle WIPP [a]
Transportation Mode	Truck only.	Three options: - Truck only - Maximum[d] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[d] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[d] commercial rail - Maximum dedicated rail	Three options: - Truck only - Maximum[d] commercial rail - Maximum dedicated rail	Truck only.
Disposal Operations	CH-TRU stacked in disposal rooms. RH-TRU placed in horizontal boreholes. RH-TRU disposal would start 6 years after CH-TRU and 7,080 m^3 (250,000 ft^3) of RH-TRU can be disposed of. 10 panel equivalents required at WIPP.[e]	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 68 panel equivalents required at WIPP.	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 75 panel equivalents required at WIPP.	CH-TRU stacked in disposal rooms. RH-TRU would be placed in either of horizontal and vertical boreholes, and/or provided extra shielding to CH-TRU levels. 71 panel equivalents required at WIPP.	No disposal. CH-TRU and RH-TRU would be in newly engineered, monitored storage at treatment sites.	No disposal. CH-TRU and RH-TRU continue to use existing storage.
WIPP Operations Time Frame	Receive and emplace waste beginning 1998 for 35 years. Decommissioning for 10 years and active institutional control for 100 years, ending in 2143.	Same as Proposed Action, lag storage for 125 years and disposal would be for 160 years, until 2158; active institutional control ending in 2268.	Waste disposal and thermal treatment to meet the LDRs would begin in 2010 after treatment facility construction. Lag storage for 115 years. Disposal would be for 150 years, until 2160. Decommissioning and active institutional control would be the same as the Proposed Action, ending in 2270.	Waste disposal and shred and grout treatment would begin in 2010 after treatment facility construction Lag storage for 155 years. Disposal would be for 190 years, until 2200. Decommissioning and active institutional control would be the same as the Proposed Action, ending in 2310.	Dismantle and close WIPP in 10 years. Thermal treatment to meet the LDRs would begin in 2010 after treatment facility construction. Package and manage indefinitely at treatment sites.	Dismantle and close WIPP. Sites generate waste for 35 years beginning in 1998. Storage at the generator-storage sites evaluated for 35 years, ending in 2033. Active institutional control at generator-storage sites until 2133.
WIPP Institutional Control Site Area	60 hectares (150 acres)	295 hectares (730 acres)	324 hectares (800 acres)	307 hectares (760 acres)	20 hectares (50 acres) (Only for 10 years during decommissioning)	20 hectares (50 acres) (Only for 10 years during decommissioning)

[a] New facilities may be constructed in the future pursuant to future NEPA review.
[b] These values correspond to the Post-Treatment Consolidated Volume and Post-Treatment Disposal Volume data in Tables 3-1 through 3-16; differences in the numbers are due to rounding. The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites.
[c] The 10 largest generator-storage sites are ANL-E, Hanford, INEL/ANL-W, LANL, LLNL, Mound, NTS, ORNL, RFETS, and SRS.
[d] Maximum rail is used to denote that 18 of the 24 sites have rail facilities nearby; the remaining sites would ship by truck. Areas and volumes have been rounded.
[e] Under the Proposed Action, the consequence analysis for RH-TRU waste is based on 7,080 cubic meters (250,000 cubic feet), the maximum disposal volume of RH-TRU waste that is allowable at WIPP under the Consultation and Cooperation Agreement. The disposal strategy is to emplace RH-TRU waste canisters in the panel room walls prior to stacking CH-TRU waste in the rooms. At startup, however, a lag in RH-TRU waste availability is anticipated that would result in only CH-TRU waste initially being disposed of. The actual amount of RH-TRU waste disposed of, therefore, may be as low as 4,300 cubic meters.



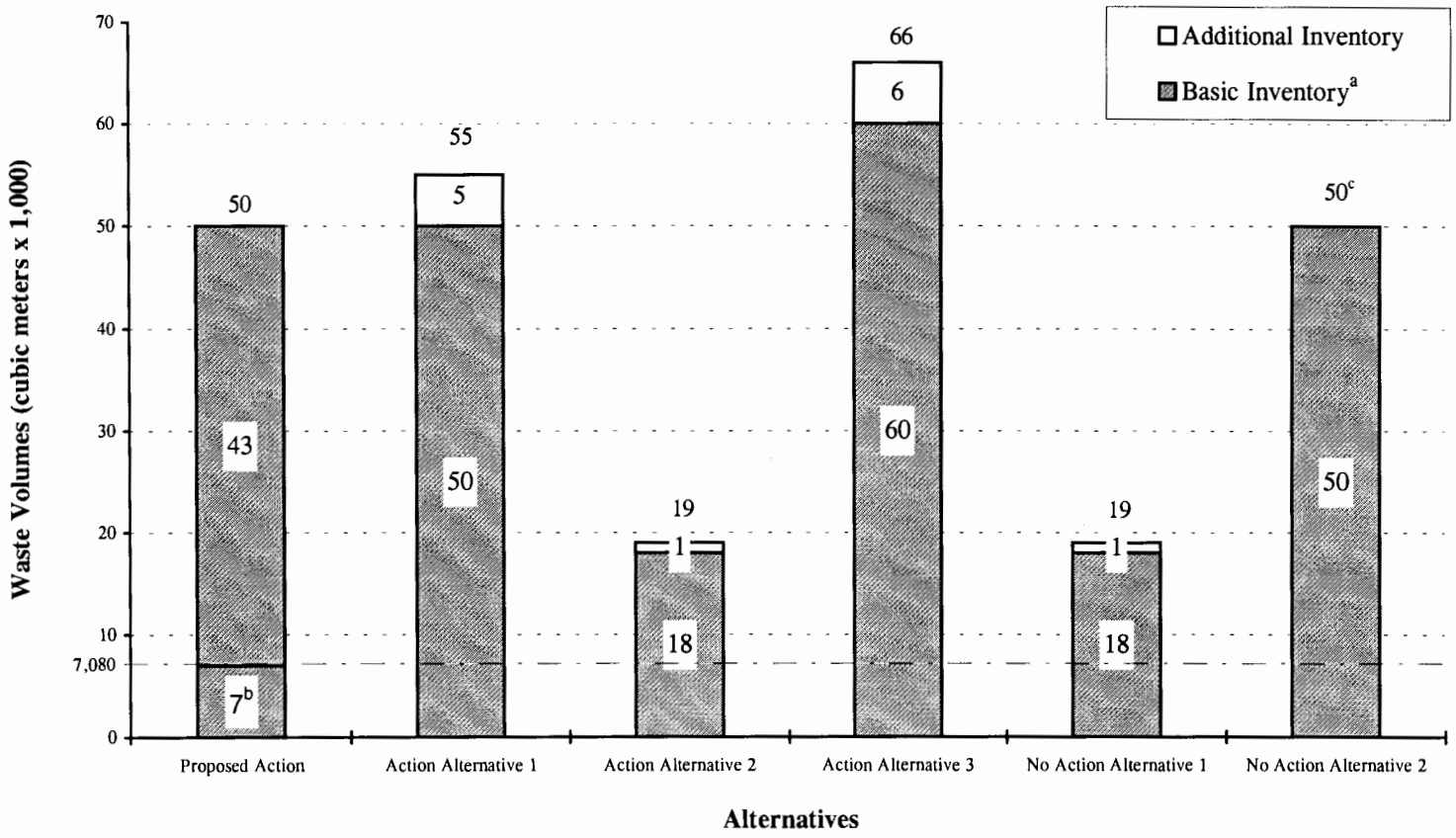
[a] The Basic Inventory consists of post-1970 and newly generated defense waste. The Basic Inventory for all alternatives has the same radionuclide inventory.

[b] The CH-TRU waste Basic Inventory is adjusted from approximately 143,000 cubic meters to 168,500 cubic meters in order to evaluate the total volume of CH-TRU waste allowable at WIPP under current laws and agreements..

[c] Includes TRU waste commingled with PCBs.

[d] Only 73,000 cubic meters of newly generated defense waste would be treated. Existing stored waste would not be treated.

Figure 3-9
CH-TRU Post-Treatment Waste Volumes by Alternative



[a] The Basic Inventory consists of post-1970 and newly generated defense waste. The Basic Inventory for all alternatives has the same radionuclide inventory.

[b] Only 7,080 cubic meters of the Basic Inventory (14 percent of the Basic RH-TRU inventory) was evaluated for WIPP disposal under the Proposed Action because of the WIPP disposal limit established under the C&C with the State of New Mexico. The excess RH-TRU waste would be treated to WAC and stored at non-WIPP treatment sites.

[c] Only 32,000 cubic meters of newly generated defense waste would be treated. Existing stored waste would not be treated.

Figure 3-10
RH-TRU Post-Treatment Waste Volumes by Alternative

the waste were released at the storage sites. The Proposed Action would be the least expensive of the action alternatives ($19.1 billion in 1994 dollars, $10.1 billion when the costs are discounted).

Action Alternative 1 could result in an estimated seven worker fatalities at the waste treatment sites and seven worker fatalities at WIPP. Truck transportation under Action Alternative 1 could result in an estimated additional 32 deaths (31 among members of the public). The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 300 deaths. The waste disposed of at WIPP under Action Alternative 1 would be isolated from the environment for more than 10,000 years, and Action Alternative 1 would effectively isolate all DOE TRU waste (except for a small quantity of PCB-commingled waste). Action Alternative 1 costs would be $50.5 billion in 1994 dollars ($16.3 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

Action Alternative 2 could result in an estimated 9 to 14 worker fatalities at the waste treatment sites and one to five fatalities to the populations in the vicinity of the treatment sites (with subalternatives 2A and 2B having higher impacts than subalternative 2C). An estimated six worker fatalities would result from disposal operations at WIPP under all subalternatives. Truck transportation under Action Alternative 2 could result in an estimated additional 14 to 19 deaths (14 to 18 among members of the public, with Action Alternative 2C having higher transportation impacts than Action Alternatives 2A or 2B). The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 30 deaths. The waste disposed of at WIPP under Action Alternative 2 would be isolated from the environment for more than 10,000 years, and Action Alternative 2 would effectively isolate all DOE TRU waste. Action Alternative 2 costs would range from $53.2 billion to $56.9 billion in 1994 dollars ($19.2 billion to $20.8 billion when discounted), depending on subalternative and assuming truck transportation (to be comparable to the Proposed Action).

Action Alternative 3 could result in an estimated nine worker fatalities at the waste treatment sites and seven worker fatalities at WIPP. Truck transportation under Action Alternative 3 could result in an estimated additional 41 deaths (40 among members of the public). The most severe accident under this alternative would be the failure of the WIPP waste hoist (with an annual frequency of 4.5×10^{-7} or less) and could result in an additional 24 deaths. The waste disposed of at WIPP under Action Alternative 3 would be isolated from the environment for more than 10,000 years, and Action Alternative 3 would effectively isolate all DOE TRU waste (except for a small quantity of PCB-commingled waste). Action Alternative 3 costs would be $59.7 billion in 1994 dollars ($18.3 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

No Action Alternative 1 could result in an estimated 12 to 14 worker fatalities at the waste treatment sites and three to five fatalities to the populations in the vicinity of the treatment sites (depending on the subalternative). No worker deaths would be estimated to result from closure activities at WIPP. Truck transportation under No Action Alternative 1 could result in an estimated zero to two deaths to members of the public. The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 30 deaths. No Action Alternative 1 would restrict access to all DOE TRU waste for 100 years, at which time the waste would either have to be disposed of or a decision would have to be made to continue storage. If the waste were released, either by loss of institutional control or by natural disaster, the thermally treated waste form would restrict migration of the waste initially, but the waste would eventually become more mobile as the vitrified waste form eroded. If the waste were

released, deaths to the public over 10,000 years would depend in part on population densities and distributions, but would be expected to be less than the 2,325 fatalities anticipated for No Action Alternative 2. Future increases in population densities near TRU waste storage sites could increase the number of estimated deaths that could result from releases of TRU waste. No Action Alternative 1 costs would range from $28.6 to $31.6 billion in 1994 dollars ($16 to $18 billion when discounted), assuming truck transportation (to be comparable to the Proposed Action).

No Action Alternative 2 could result in an estimated two worker fatalities at the waste storage sites and no worker deaths from closure activities at the WIPP site. No transportation is assumed under No Action Alternative 2, and no deaths would result. The most severe accident under this alternative would be the destruction of a storage facility as a result of a beyond-design-basis earthquake (with an annual frequency of 1×10^{-5} or less) and could result in an additional 300 deaths. No Action Alternative 2 would restrict access to the currently stored and newly generated portion of DOE TRU waste for 100 years, at which time the waste would either have to be disposed of or a decision would have to be made to continue storage. If the waste were released, either by loss of institutional control or by natural disaster, estimated deaths would total 2,325 over 10,000 years given current population densities and distributions. Future increases in population densities near TRU waste storage sites could increase the number of estimated deaths that could result from releases of TRU waste. No Action Alternative 2 costs would be $2.7 billion in 1994 dollars ($1.8 billion when discounted).

Table 3-18 is a summary table that compares the more notable impacts from within the Proposed Action and the alternatives.

Table 3-18
Summary of SEIS-II Environmental Impacts

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Land Use and Management									
Treatment Facility Sites	No substantial impacts identified beyond the treatment facilities. Treatment facilities would require no more than 11 hectares, less than 1% of land available at each site for each alternative. Treatment facilities, therefore, could be located in developed areas or areas appropriate for development. Sensitive areas, including wetlands, flood plains, sensitive habitats, and cultural resource areas would be avoided.								No substantial impacts. Only newly generated waste would be treated. No new treatment facilities would be constructed.
WIPP (during operations)	DOE would occupy the land transferred by the LWA and lease some other land. WIPP would continue to limit drilling and mining activities, and grazing and public access to the site. No other impacts would occur to local land use beyond the site.						Impacts would be minimal because no waste would be emplaced.		
WIPP (area impacted by closure)	60 hectares	295 hectares	324 hectares	324 hectares	324 hectares	307 hectares	20 hectares	20 hectares	20 hectares
Air Quality									
Treatment Facility Sites (Emissions for sites and pollutants not specifically noted would be less than 10% of the most stringent applicable regulatory standard).	RFETS, CO, 17%.		RFETS, radionuclides, 134%. SRS, radionuclides, 48%. RFETS, CO, 24%. INEL, PM_{10} 10%.	INEL, radionuclides, 10%. SRS, radionuclides, 48%. INEL, PM_{10}, 10%.	WIPP, radionuclides, 319%. WIPP, SO_2, 12%. WIPP, PM_{10}, 25%.	RFETS, CO, 20%.	RFETS, radionuclides, 134%. SRS, radionuclides, 48%. RFETS, CO, 24%, INEL, PM_{10}, 10%.	INEL, radionuclides, 10%. SRS, radionuclides, 48%. INEL, PM_{10}, 10%.	No substantial impacts identified. Only minimal treatment would occur.
WIPP Operations (percent of applicable EPA or state standard)	Annual average: negligible increases of O_3 and lead; less than 2% increases in PM_{10}, NO_2, and SO_2. Short-term (24-hour) emission limits: PM_{10} - 57%, NO_2 - 65%, SO_2 - 7%, CO - 3% of standards, releases of lead and ozone would be minimal.						WIPP would not be operated. WIPP would be dismantled.		
Biological Resources									
Treatment Facility Sites	Threatened and endangered species appear at many of the proposed treatment sites and could potentially be impacted. Such species and their critical habitats would be avoided through appropriate consultation, site selection, monitoring, and mitigation measures. Because the treatment sites would require less than 1% of the land available at any site, critical habitats could be avoided at most sites.								No impacts because only minimal treatment would occur.
WIPP (disturbed land area)	Federally- or state-listed or protected, threatened, endangered, and proposed species occur in Eddy County and potentially at the WIPP site, although there have been no threatened, endangered, or proposed species or critical habitats recently observed at the WIPP site by DOE during completion of its recent biennial environmental compliance reports. DOE is conducting new biological surveys at the WIPP site. DOE will prepare a biological assessment and consult with federal and state agencies as appropriate, and include such information in the Final SEIS-II. No impacts to biodiversity or ecosystem balance would be expected. Impacts to other plant and animal species may occur during closure and construction of a berm around the WIPP site. The affected area would differ based on the areas listed above under land use.						Minimal impacts during closure of current facility.		

Table 3-18
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Cultural Resources									
Treatment Facility Sites	Although cultural resources are present at many sites, specific treatment facility locations are unknown. Acreage need at any one site is 11 hectares or less. Potential impacts will be avoided or mitigated based on site-specific cultural resource surveys.								No impacts. Treatment would be minimal.
WIPP Resource Sites Potentially Impacted (during operations)	None.						No impacts. WIPP would not be operated.		
WIPP Resource Sites Potentially Impacted (during closure)	Two.	Eleven due to larger surface closure area.					No impacts for the no action alternatives. Closure would only involve the 20 acres on which current facilities have been built.		
Noise									
Treatment Sites	Negligible increase in noise due to waste transportation or treatment facility operation because treatment facilities would probably be placed at industrial-type sites along high-traffic volume corridors. Project-specific impacts to sensitive receptors could occur. Assessment of potential impacts would be conducted in site-wide or project-specific NEPA documentation.								No impacts because transportation would not occur and treatment would be minimal.
WIPP	Negligible increase in noise due to additional daily truck or train traffic. Only 8 trucks per day would travel to WIPP if trucks are used; only 13 to 16 rail cars per week if trains are used.						Not applicable to the no action alternatives. No transportation to WIPP would occur and WIPP would not be operated.		
Water Resources and Infrastructure									
Treatment Sites 1. Water 2. Power 3. Wastewater 4. On-site Transportation	3. Hanford - 5.9% 4. Hanford, INEL, and LANL - minor impacts		2. INEL - 7% 3. Hanford - 7.8% 4. Hanford, INEL, and LANL - minor impacts	2. INEL - 7% 3. Hanford - 7.8% 4. Hanford, and INEL - minor impacts	2. INEL - 7%; WIPP - 50% 3. WIPP - 80% 4. WIPP - 162%; Hanford - minor impacts	2. INEL - 6.4% 3. Hanford - 7% 4. Hanford, INEL, and LANL - minor impacts	2. INEL - 7% 3. Hanford - 7.8% 4. Hanford, INEL, and LANL - minor impacts	2. INEL - 7% 3. Hanford - 7.8% 4. Hanford, and INEL - minor impacts	No impacts.
Disposal Operations at WIPP	Annual incremental infrastructure impacts at WIPP would be negligible and within capacity for disposal operations.						Decreasing use of resources, none after decommissioning of WIPP.		

Table 3-18
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Socioeconomics									
Treatment/Storage Sites									
Life-Cycle Costs (millions of 1994 dollars)	11,800	21,400	27,700	30,000	28,700	24,400	27,300	27,700	1,908
Employment (additional ROI jobs - direct, indirect, and induced)	5,700	11,700	15,700	15,500	10,600	13,300	15,700	15,500	800
Disposal Operations at WIPP									
Life-Cycle Costs (millions of 1994 dollars)	5,300	24,600	23,300	23,300	23,300	28,500	850	850	850
Goods & Services (millions of 1994 dollars)	17,700	80,800	75,800	75,800	147,000	96,000	-524	-524	-524
Employment (job-years)	118,000	539,400	505,700	505,700	982,700	640,500	-3,370	-3,370	-3,370
Labor Income (millions of 1994 dollars)	4,200	19,200	18,000	18,000	35,000	22,800	-120	-120	-120
Total Life-Cycle Cost by Mode of Transportation (millions of 1994 dollars); discounted totals using a 4.1 percent annual inflation rate are presented in parentheses									
Total Life-Cycle Costs--Truck	19,100 (10,100)	50,500 (16,300)	53,200 (19,400)	56,300 (20,800)	56,900 (20,400)	59,700 (18,300)	28,600 (16,000)	31,600 (18,000)	No shipments of TRU waste would occur under this alternative. Total life-cycle cost without transportation is 2,800.
Total Life-Cycle Costs--Regular Rail	No rail transportation analyzed in this alternative.	47,500 (15,800)	51,600 (19,200)	54,700 (20,600)	53,200 (19,800)	55,000 (17,700)	28,600 (15,900)	31,500 (18,000)	
Total Life-Cycle Costs--Dedicated Rail		57,300 (17,300)	56,000 (19,900)	59,400 (21,400)	61,800 (21,300)	68,500 (19,500)	28,800 (16,100)	32,600 (18,500)	
Transportation									
Truck									
Number of Truck Shipments to Consolidation Sites and WIPP	CH - 29,766 RH - 7,957	CH - 41,003 RH - 62,162	CH - 25,363 RH - 21,895	CH - 25,361 RH - 21,895	CH - 41,151 RH - 21,895	CH - 67,309 RH - 74,606	CH - 485 RH - 1,681	CH - 8,413 RH - 1,681	No shipments of TRU waste would occur under this alternative.
Nonradiological Truck Impacts									
Truck Accidents	76	237	107	114	140	331	3	14	
Truck Injuries	48	148	66	69	87	208	0	13	
Truck Fatalities	6	19	9	9	12	25	0	1	
Truck Pollution Fatalities	0.2	0.5	0.2	0.3	0.3	0.7	5.0E-3	0.04	

Table 3-18
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Radiological Truck Impacts									No shipments of TRU waste would occur under this alternative.
Accident-Free Population Impacts to Crews (LCFs)	0.3	0.7	0.4	0.4	0.6	1.0	5.2E-3	0.07	
Accident-Free Population Impacts to the Public (LCFs)	3.0	11	5	5	6	14	0.1	0.5	
Highest Lifetime Accident-Free Impact to MEIs (probability of an LCF)	3.3E-3	8.1E-3	7.0E-3	7.0E-3	7.1E-3	7.0E-3	Not Analyzed.	Not Analyzed.	
Rail									
Number of Rail Shipments to WIPP	Transportation by rail not included in this alternative.	CH - 20,502 RH - 31,081	CH - 12,682 RH - 10,948	CH - 12,681 RH - 10,948	CH - 20,576 RH - 10,948	CH - 33,655 RH - 37,303	CH - 243 RH - 841	CH - 4,207 RH - 841	
Nonradiological Rail Impacts									
Fatalities Using Regular Rail Service		9	4	4	5	13	0.09	0.6	
Fatalities Using Dedicated Rail Service		216	97	103	127	303	2	16	
Radiological Rail Impacts									
Accident-Free Population Impacts to Crews (Regular and Dedicated) (LCFs)		0.03	0.02	0.02	0.03	0.5	3.2E-4	3.2E-3	
Accident-Free Population Impacts to the Public (Regular and Dedicated) (LCFs)		1.4	0.7	0.7	0.8	1.9	0.02	0.08	
Accidents									
Transportation Accidents (Truck)									
Population Impacts with Conservative Inventory (LCFs)	CH - 16 RH - 16	CH - 16 RH - 16	CH - <1 RH - <1	CH - <1 RH - <1	CH - 16 RH - <1	CH - 16 RH - 16	CH - 16 RH - 16	CH - 16 RH - 16	
Population Impacts with Average Inventory (LCFs)	CH - 3 RH - 0.04	CH - 3 RH - 0.04	CH - <1 RH - <1	CH - <1 RH - <1	CH - 3 RH - <1	CH - 3 RH - 0.04	CH - 3 RH - 0.04	CH - 3 RH - 0.04	
MEI Impact with Conservative Inventory (probability of an LCF)	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	CH - 2E-4 RH - 2E-4	CH - 2E-4 RH - 2E-4	CH - 0.06 RH - 2E-4	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	CH - 0.06 RH - 0.06	
MEI Impact with Average Inventory (probability of an LCF)	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	CH - 2E-4 RH - 2E-6	CH - 2E-4 RH - 2E-6	CH - 0.04 RH - 2E-6	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	CH - 0.04 RH - 7E-4	
Aggregate Potential Truck Accident Impacts to Populations Along All Transportation Routes (LCFs)	0.4	0.8	0.4	0.4	0.7	1.2	6.8E-3	0.02	

Table 3-18
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Transportation Accidents (Rail)									No shipments of TRU waste would occur under this alternative.
Population Impacts with Conservative Inventory (LCFs)	No rail transportation is proposed under the Proposed Action.	CH - 32 RH - 32	CH - <1 RH - <1	CH - <1 RH - <1	CH - 32 RH - <1	CH - 32 RH - 32	CH - 32 RH - 32	CH - 32 RH - 32	
Population Impacts with Average Inventory (LCFs)		CH - 6 RH - 0.08	CH - <1 RH - <1	CH - <1 RH - <1	CH - 6 RH - <1	CH - 6 RH - 0.08	CH - 6 RH - 0.08	CH - 6 RH - 0.08	
MEI Impact with Conservative Inventory (probability of an LCF)		CH - 0.12 RH - 0.12	CH - 4E-4 RH - 4E-4	CH - 4E-4 RH - 4E-4	CH - 0.12 RH - 4E-4	CH - 0.12 RH - 0.12	CH - 0.12 RH - 0.12	CH - 0.12 RH - 0.12	
MEI Impact with Average Inventory (probability of an LCF)		CH - 0.08 RH - 1E-3	CH - 3E-4 RH - 4E-6	CH - 3E-4 RH - 4E-6	CH - 0.08 RH - 4E-6	CH - 0.08 RH - 1E-3	CH - 0.08 RH - 1E-3	CH - 0.08 RH - 1E-3	
Aggregate Potential Rail Accident Impacts (LCFs) to Populations Along All Rail Routes		0.8	0.4	0.4	0.7	1.2	6.8E-3	0.02	
Human Health									
Routine Radiological Impacts (LCFs)[a]									
Treatment									
Involved Worker Population	2	3	5	5	3	4	5	5	8E-2
Noninvolved Worker Population Maximum Exposed Noninvolved Worker	2E-5 7E-9	2E-5 8E-9	0.5 3E-4	0.3 2E-4	0.09 3E-4	4E-5 2E-8	0.5 3E-4	0.3 2E-4	2E-5 7E-9
Public Population MEI	2E-4 9E-9	2E-4 1E-8	5 9E-5	3 2E-5	1 3E-4	4E-4 2E-8	5 9E-5	3 2E-5	2E-4 9E-9
***WIPP Operations[b]* (LCFs)[a]**							**Storage Impacts at Treatment Sites Only - No WIPP Operations**		
Involved Worker Population	0.6	0.8	0.2	0.2	0.2	0.2	0.4	0.4	1
Noninvolved Worker Population Maximum Exposed Noninvolved Worker	4E-4 4E-7	4E-4 4E-7	2E-4 2E-7	2E-4 2E-7	2E-4 2E-7	3E-4 3E-7	2E-2 1E-6	2E-2 1E-6	4E-2 4E-5
Public Population MEI	3E-4 3E-7	3E-4 5E-7	5E-5 1E-7	5E-5 1E-7	5E-5 1E-7	2E-4 3E-7	1E-3 2E-7	7E-4 2E-9	1E-2 2E-6
Lag Storage[c] Public Population Impacts Lag Storage Noninvolved Worker Population	No lag storage for the Proposed Action.	1E-2 4E-2	1E-3 2E-2	6E-4 2E-2	1E-4 4E-4	2E-3 4E-2	No lag storage for the no action alternatives.		
Excess RH-TRU Waste Storage Public Population Impacts	2E-5	No excess RH-TRU waste is considered in these alternatives; such RH-TRU waste is reflected in the inventory/waste volumes for these alternatives.							
Excess RH-TRU Waste Storage Noninvolved Worker Population	4E-5								

Table 3-18
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Routine Hazardous Chemical Impacts (Cancer Incidence)									
Treatment at Treatment Sites									
Involved Worker Population	4E-5	6E-5	2E-4	2E-4	4E-4	1E-4	2E-4	3E-4	4E-6
Noninvolved Worker Population	1E-7	1E-7	1E-7	1E-7	1E-7	3E-7	1E-7	1E-7	1E-7
Maximum Exposed Noninvolved Worker	5E-11	5E-11	4E-11	4E-11	4E-11	5E-11	4E-11	4E-11	5E-11
Public Population	4E-7	4E-7	4E-7	3E-5	5E-7	8E-7	4E-7	3E-7	4E-7
Maximum Exposed Individual	8E-12	8E-12	7E-12	6E-12	9E-12	1E-11	7E-12	7E-12	8E-12
WIPP Operations[a]							**Storage Impacts at Treatment Sites Only - No WIPP Operations**		
Involved Worker Population	1E-2	3E-2	No impacts because the TRU waste would be thermally treated.			7E-3	None because TRU waste would be thermally treated.		4E-2
Noninvolved Worker Population	1E-4	1E-4				5E-5			2E-3
Maximum Exposed Noninvolved Worker	1E-7	9E-8				5E-8			2E-7
Public Population	2E-5	2E-5				1E-5			2E-3
Maximum Exposed Individual	3E-8	2E-8				1E-8			4E-8
Lag Storage[c] Public Population	No lag storage for the Proposed Action.	3E-3				2E-3	None because there is no lag storage for the no action alternatives.		
Lag Storage Noninvolved Worker Population		5E-3				9E-3			
Excess RH-TRU Waste Storage Public Population Impacts	3E-4	No excess RH-TRU waste is considered in these alternatives; such RH-TRU waste is reflected in the inventory/waste volumes for these alternatives.							
Excess RH-TRU Waste Storage Noninvolved Worker Population	6E-4								
Selected Facility Accidents[a]									
Treatment Facility Sites (Earthquake) LCFs									
Maximally Exposed Noninvolved Worker	1E-3	1E-3	0.03	0.03	0.01	0.02	0.03	0.03	1E-3
Maximally Exposed Individual	8E-4	8E-4	0.02	0.02	0.01	0.01	0.02	0.02	8E-4
Public Population	1	1	30	30	1	10	30	30	1
Storage Facility Sites (Earthquake) LCFs									
Maximally Exposed Noninvolved Worker	7E-3	0.7	0.02	0.02	0.03	0.02	0.02	0.02	0.7
Maximally Exposed Individual	6E-4	0.07	3E-3	3E-3	3E-4	3E-3	3E-3	3E-3	0.07
Public Population	2	300	10	10	2	10	10	10	300
WIPP Disposal (Hoist Failure, frequency of 4.5E-7) LCFs									
Maximally Exposed Noninvolved Worker	0.05	0.05	0.3	0.3	0.3	0.3	No impacts because disposal does not occur under the no action alternatives.		
Maximally Exposed Individual	0.07	0.07	0.4	0.4	0.4	0.4			
Public Population	4	4	24	24	24	24			

Table 3-18
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Industrial Safety									
Waste Treatment (fatalities)	4	4	9	7	6	5	9	7	0.7
Construction and Operations (fatalities)	2	6	6	6	6	7	0.4	0.4	0.6
Performance Assessment of Treatment Sites and WIPP									
Treatment Sites - Human Intrusion									
Radiological Impacts (probability of an LCF)									
Drilling Crew Member	Does not apply to these alternatives because there is no waste at the treatment sites under the Proposed Action and the action alternatives, and TRU waste is managed indefinitely under No Action Alternatives 1A and 1B.								7E-6 to 4E-4
Gardener									4E-3 to 0.07
Scavenger									7E-4 to 0.02
Family Farm									> 1
Environmental Release									
MEI (probability of an LCF)	8.5E-4	Does not apply to these alternatives because there is no waste at the treatment sites under the Proposed Action and the action alternatives. For No Action Alternatives 1A and 1B, it was assumed the waste would be managed forever.							8E-7 to 7E-3
Population (LCFs)	<2								3E-4 to 21
Aggregate Population Impacts over 10,000 years	<0.9 due to excess RH-TRU waste[d]	Does not apply to these alternatives because there is no waste at the treatment sites.					Less than No Action Alternative 2[e]	Less than No Action Alternative 2[e]	2,325
Hazardous Chemical Impacts									
Environmental Release (Cancer Incidence)									
MEI	Does not apply to these alternatives because there is no waste at the treatment sites under the Proposed Action and the action alternatives, and TRU waste is managed indefinitely under No Action Alternative 1.								2E-7 to 5E-3
Population									8E-9 to 7E-4
WIPP - Human Intrusion (based on the intrusion in the repository scenario)									
Radiological Impacts Drilling Crew Member (probability of an LCF; dashes indicate no analyses were performed because scenarios are inapplicable)									
CH-TRU Waste Panel	---	3E-4	5E-4	5E-4	5E-4	2E-4	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
RH-TRU Waste Panel	---	9E-5	7E-5	7E-5	7E-5	9E-5			
Mixed CH-TRU and RH-TRU Panel	4E-4	3E-4	---	---	---	3E-4			
Radiological Impacts Site Geologist (probability of an LCF)									
CH-TRU Waste Panel	4E-9	4E-9	1E-8	1E-8	1E-8	3E-9	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
RH-TRU Waste Panel	3E-7	4E-7	1E-6	1E-6	1E-6	3E-7			
Hazardous Chemical Impacts (Cancer Incidence)									
Intruder (fraction of IDLH value)	4E-3	4E-3	5E-4	5E-4	5E-4	1E-3	Does not apply to these alternatives. No waste would be disposed of at WIPP.		

Table 3-18
Summary of SEIS-II Environmental Impacts-Continued

Consequence Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Environmental Justice									
Treatment sites and WIPP	Although possible, disproportionately high and adverse effects on minority or low-income populations are not expected.				Impacts are possible at WIPP during treatment.	Although possible, disproportionately high and adverse effects on minority or low-income populations are not expected.			
TRU Waste Retrieval (of one panel of waste before repository closure)									
Population Exposures (LCFs)									
Involved Worker Population	0.03	0.03	0.03	0.03	0.03	0.03	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Noninvolved Worker Population	1E-3	1E-3	1E-3	1E-3	1E-3	1E-3			
Public Population	3E-5	3E-5	3E-5	3E-5	3E-5	3E-5			
Transportation									
Occupational	0.03	0.03	0.03	0.03	0.03	0.03	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Nonoccupational	0.3	0.3	0.3	0.3	0.3	0.3			
Vehicle-Related Fatalities	0.5	0.5	0.5	0.5	0.5	0.5			
TRU Waste Recovery (of all waste after repository closure)									
Population Exposures (LCFs)									
Involved Worker Population	8	8	8	8	8	8	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Noninvolved Worker Population	0.3	0.3	0.3	0.3	0.3	0.3			
Public Population	0.2	0.2	0.2	0.2	0.2	0.2			
Transportation									
Occupational Fatalities	1	1	1	1	1	1	Does not apply to these alternatives. No waste would be disposed of at WIPP.		
Nonoccupational Fatalities	14	14	14	14	14	14			
Pollution-Health Effects Fatalities	6	6	6	6	6	6			
Vehicle-Related Fatalities	213	213	213	213	213	213			

[a] The probability of an LCF occurring to the MEI or maximum exposed noninvolved worker, and the number of LCFs to the populations.
[b] Under the no action alternatives, this category represents impacts from storage.
[c] Lag storage is storage pending shipment to WIPP. Lag storage does not include long-term storage of waste (such as excess RH-TRU waste under the Proposed Action) that will not be shipped to WIPP.
[d] Results are based on the analysis of No Action Alternative 2.
[e] If institutional control were lost, fatalities would be expected although the LCFs would be less than No Action Alternative 2.

3.5 REFERENCES CITED IN CHAPTER 3

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CHAPTER 4

CHAPTER 4
DESCRIPTION OF THE AFFECTED ENVIRONMENTS

This chapter describes the affected environments at the Waste Isolation Pilot Plant (WIPP) site and at the ten major generator-storage sites. The WIPP site is discussed in detail with emphasis on the changes that have occurred and new information that has been determined since the publication of the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) in 1990 (DOE 1990).

4.1 EXISTING ENVIRONMENT AT THE WIPP

The passage of the WIPP Land Withdrawal Act (LWA), results of recent environmental studies, and changes to various aspects of the existing environment have generated new information concerning the environment at the WIPP site. The following sections update Sections 4.1.1 through 4.3.5 of SEIS-I (DOE 1990).

4.1.1 Land Use and Management

The U.S. Department of Energy (DOE or the Department) defines the region of influence (ROI) for land use impacts as WIPP plus ". . . the site and the area immediately adjacent to the site" (DOE 1995h).[1] Thus, for WIPP, the area of consideration for land use includes privately owned ranches and Bureau of Land Management (BLM) lands, including some leased as mineral and grazing lands immediately adjacent to the WIPP site. The *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) states that almost 7,700 hectares (19,000 acres) of land surrounding WIPP were committed to the WIPP project. It notes that the dominant use of the land within 16 kilometers (10 miles) of the site is grazing, with lesser amounts used for oil and gas extraction and potash mining. BLM owns most of this land. Two ranches are located within 16 kilometers (10 miles) of the WIPP site while the closest town, Loving, New Mexico, is 29 kilometers

CHANGES IN SITE LAND USE AND MANAGEMENT

Since publication of SEIS-I, DOE has made the following changes in land use. These changes are largely due to the planning-basis WIPP Waste Acceptance Criteria (WAC) and the Land Management Plan.

- *Wildlife Management* - DOE initiated a multi-year research effort to document the population and ecology of several species, and additional seeding of reclamation sites was undertaken.
- *Cultural Resources Management* - DOE created a comprehensive WIPP archeological database.
- *Vegetation Management* - DOE now monitors vegetation for evidence of stress induced by climate and salt tailings.
- *Rights-of-Way* - In 1994, DOE requested and was granted permission by BLM to construct a short access road.
- *Emergency and Facility Security* - DOE has published three plans on emergency and facility security.
- *Groundwater Surveillance* - DOE has installed seven new wells to monitor water quality.

[1] Currently this ROI includes only two working ranches. No towns are included.

(18 miles) away. The federal government or the State of New Mexico owns most of the land within 50 kilometers (30 miles) of the WIPP site. Within 80 kilometers (50 miles) of the site, there is dryland farming, irrigated farming along the Pecos River, and some forest, wetland, and urban land (see Figure 4-1).

SEIS-I (DOE 1990) notes the release of approximately 4,450 hectares (11,000 acres) of previously restricted land for unrestricted use, allowing exploration for and development of mineral resources and permanent habitation. It describes a land withdrawal boundary, which defines the WIPP site, as encompassing 16 sections (4,146 hectares [10,240 acres]) of federal land in Township 22 South, Range 31 East (Figure 4-2). This boundary was delineated so as to extend at least 1.6 kilometers (1 mile) beyond any WIPP underground development.

The type of land use surrounding WIPP has not changed substantially since the preparation of SEIS-I, although the level of development has increased. The site has been divided into four areas under DOE control (Figure 4-2). A chain-link fence surrounds the innermost "Property Protection Area," which includes the surface facilities. Surrounding this inner area is the "Exclusive Use Area," set off by a barbed-wire fence. Enclosing these areas is the "Off-Limits Area," which is unfenced to allow livestock grazing but, like the other two, is patrolled and posted against trespass or other land uses. Beyond the "Off Limits Area," within the 16-section WIPP site, the land is managed under the traditional public land use concept of multiple use. Mining and drilling for purposes other than support of the WIPP project, however, are restricted (DOE 1995f).

On October 30, 1992, the President signed into law the LWA (Public Law 102-579). This Act transferred responsibility for management of the WIPP withdrawal area from the Secretary of the Interior to the Secretary of Energy. The land is permanently withdrawn from all forms of entry, appropriation, and disposal under the public land laws and is reserved for uses associated with the purposes of WIPP. LWA establishes certain rights and responsibilities, one of which was the preparation of a Land Management Plan published in 1993 (DOE 1993a).

DOE's WIPP Land Management Plan establishes management objectives and planned actions for the use of the withdrawn land until the end of the decommissioning phase. The plan promotes the concept of multiple-use management for the surface area of the withdrawn land and establishes a goal of minimizing land use restrictions where possible. The plan also provides opportunity for participation in the land use planning process by the public, and local, state, and federal agencies.

The Land Management Plan lists 13 areas of concern: wildlife, cultural resources, grazing management, recreation, mining and oil and gas production, rights-of-way, access, emergency and facility security, fire management, water service, groundwater surveillance, salt tailings, and reclamation. The following is a summary of the progress made toward implementing this plan. Details of these actions can be found in the *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1994* (DOE 1995f).

Recent efforts in the area of wildlife management include initiating a multi-year research investigation into the ecology and life history of resident raptor populations, with emphasis on the Harris hawk (*Parabuteo unicinctus*); appraisals of populations of small nocturnal mammals; and the additional seeding of reclamation sites to increase soil stabilization.

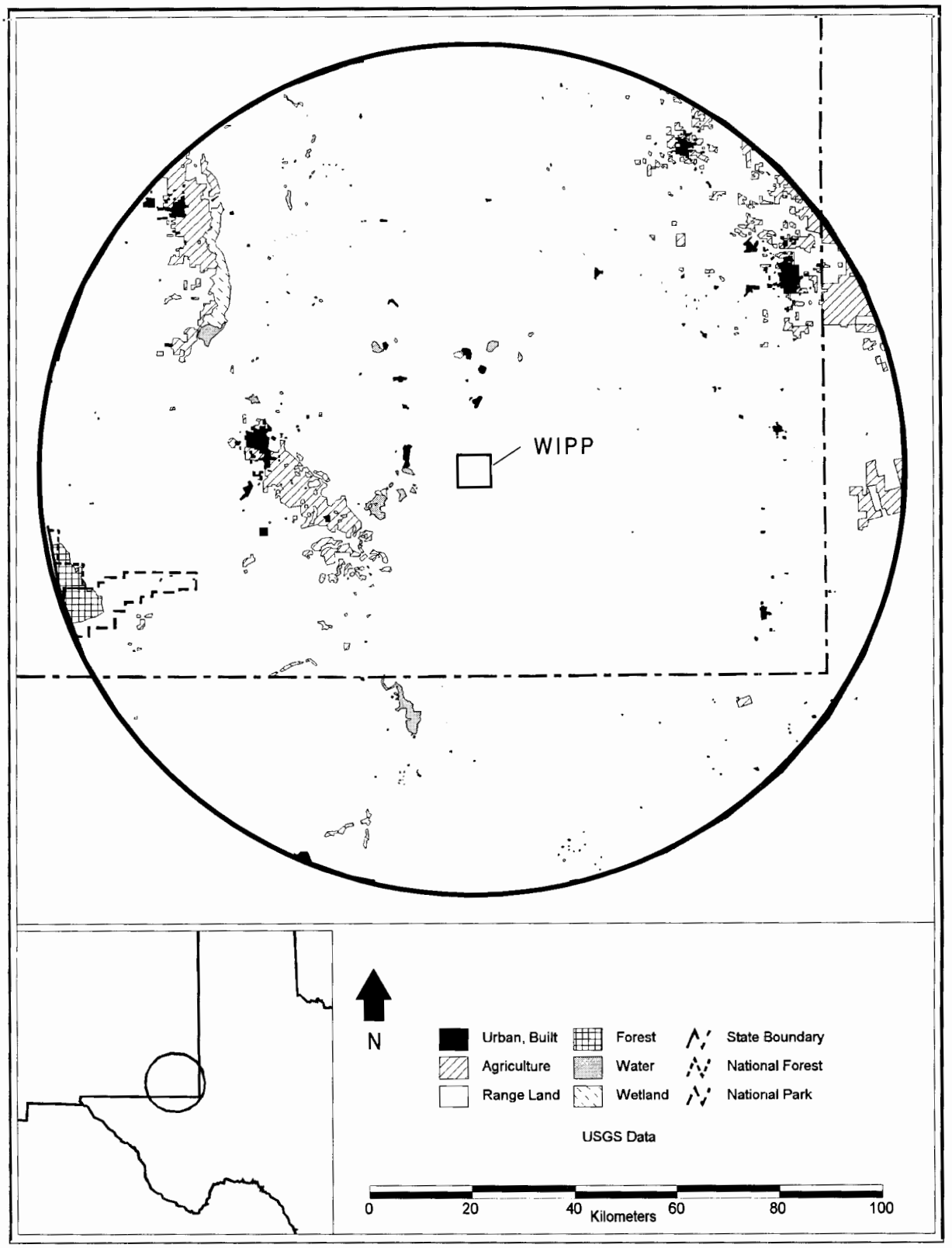


Figure 4-1
Land Use Within 80 Kilometers (50 Miles) of WIPP

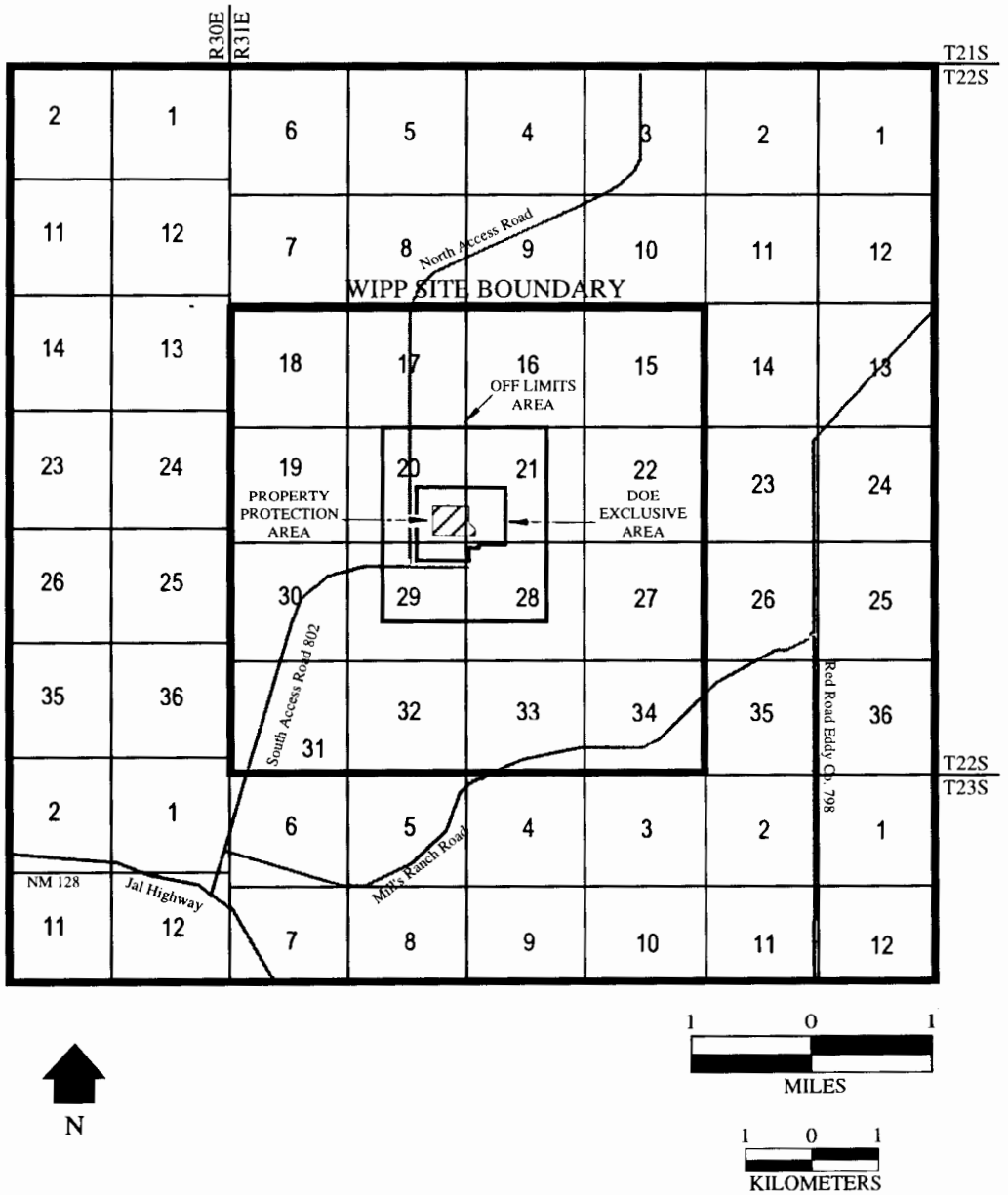


Figure 4-2
WIPP Areas

Activities concerning cultural resources management include creating a comprehensive WIPP site archeological database, developing a Memorandum of Understanding between DOE and the Department of Interior concerning responsibility for archeological sites on WIPP land, obtaining approval to construct an access road from the State Historic Preservation Officer, and avoiding previously known archeological sites while carrying out archeological surveys.

DOE's intent concerning grazing management is to continue current management practices unless a need develops to modify them. To that end, planned actions include continuing vegetative monitoring in the withdrawal area, continuing the management of grazing allotments under the principles of multiple-use management and sustained yield, and continuing range management practices in accordance with appropriate acts and regulations.

DOE intends to maintain recreation resource values and to continue to provide opportunities for individuals to participate in recreational activities within designated parts of the withdrawal area. Planned actions include environmental monitoring of the withdrawal area, regulating off-road vehicle use, and determining the potential effect of anticipated projects or other activities on the visual quality of the landscape. DOE would also allow hunting and trapping in accordance with applicable regulations.

The Land Management Plan incorporates the restrictions of the LWA. The subsurface of the withdrawal area is reserved for exclusive use of WIPP. No surface or subsurface mining unrelated to the WIPP project, including slant drilling from outside the boundary area, is permitted. The exception is two tracts of land within the withdrawal area that are leased from BLM for oil and gas development below 1,829 meters (6,000 feet). In instances where operators seek permits to drill or mine at a location close to the withdrawal boundary, DOE will request drilling information to detect any potential for subsurface encroachment into the WIPP repository. Should there be potential for encroachment, the operator will be required to modify the drilling activity in accordance with existing memorandums of understanding or similar agreements.

BLM administers rights-of-way in coordination with DOE. The objective is to ensure safe and adequate access to WIPP while protecting the security of personnel and facilities. Consideration is also being given to closing parts of some access roads to protect the health and safety of the public. In 1994, DOE requested and was granted permission to construct short access roads from main roadways to the sites of wells.

Changes concerning emergency and facility security preparedness include implementing plans to minimize impacts during emergencies. These plans include the WIPP Emergency Plan (WP 12-9), the WIPP Resource Conservation and Recovery Act (RCRA) Contingency Plan (WP 02-12), and the WIPP Security Plan.

Fire management is concerned with wildfires in the withdrawal area. The Land Management Plan provides for immediate notification of the BLM Carlsbad Fire Control Officer upon detection of a wildfire. WIPP personnel may call upon help from various sources or may opt to have BLM fight a wildfire, if conditions warrant that choice.

Water service for WIPP is provided by a DOE-constructed water line from Carlsbad's system to the WIPP site and is made possible by a contract between DOE and the City of Carlsbad.

The groundwater surveillance program adjusts surveillance activities, if necessary, and plugs and seals wells when they are no longer necessary. In support of this program, seven new wells were installed for water quality sampling.

The Land Management Plan provides for the management of the salt pile in an environmentally sound manner until such time as a determination is made on its disposition. Salt backfill is not required for subsidence control or repository performance but may be placed into the repository for final disposition. Management of the salt pile may include monitoring vegetation for evidence of stress from salt; selling or disposing of unneeded salt under the Materials Act of 1947; ripping, leveling, and adding topsoil to the salt stockpile base; and reseeding with seed mixes reflecting indigenous plant species.

Recent activities in the area of land reclamation have included decommissioning numerous fenced areas, removing rebar from study areas to alleviate safety hazards to personnel and livestock, and carrying out additional reclamation measures in selected problem areas such as drainages and eroded slopes.

4.1.2 Air Quality, Climate, and Noise

The Environmental Protection Agency (EPA) has classified Eddy County, New Mexico, where WIPP is located, as an attainment area for all six of the criteria pollutants under the National Ambient Air Quality Standards (NAAQS). WIPP is also in a Class II Prevention of Significant Deterioration (PSD) area, and any new sources of emissions would have to adhere to the standards for such an area (META/Berger 1995). The Class I PSD areas nearest to WIPP are: Carlsbad Caverns National Park, which is approximately 61 kilometers (38 miles) southwest of WIPP, and Guadalupe Mountains National Park, which is approximately 100 kilometers (62 miles) southwest of WIPP.

The measurement of selected air pollutants at WIPP began in 1976 and was reported in FEIS (DOE 1980). SEIS-I (DOE 1990) stated that seven classes of EPA-regulated atmospheric gases had been monitored since August 27, 1986. These gases are carbon monoxide (CO), hydrogen sulfide (H_2S), ozone (O_3) precursors, oxides of nitrogen (NO_x), and sulfur dioxide (SO_2). Total suspended particulates (TSP) were also monitored in conjunction with the air monitoring programs of EPA's Regulatory and Environmental Surveillance Programs. As reported in SEIS-I, the results of this monitoring program indicated that air quality in the area of WIPP usually met state and federal standards. SEIS-I indicated that, during periods of high wind and blowing sands, the TSP standards were occasionally exceeded, but the ambient air quality standard for sulfur dioxide had been infrequently exceeded.

CHANGES IN AIR QUALITY MONITORING

Since publication of SEIS-I, the following changes have occurred:

- *Monitoring of Pollutant Gases* - On October 30, 1994, after DOE notified EPA, monitoring of criteria air pollutants at the WIPP Ambient Air Monitoring Station was discontinued because it was no longer required by regulation.
- *Volatile Organic Compound (VOC) Monitoring Program* - The VOC monitoring program was established at WIPP in 1991 after the EPA determined that air migration of VOC target compounds would be a potential concern during both testing and operations at the facility.

Air quality monitoring data collected since 1990 are summarized in annual WIPP site environmental reports (DOE 1992, 1993b, 1994a, and 1995f). WIPP has completed inventories of potential pollutants and emissions in accordance with EPA and New Mexico Air Quality Control Regulations (AQCR). Based on these inventories, WIPP has no permitting or reporting requirements at this time except for those applying to two primary backup diesel generators. An AQCR operating permit was issued for the two diesel generators in 1993 (DOE 1995f). These diesel generators are assumed to emit four pollutants (nitrogen dioxide (NO_2), SO_2, CO and particulate matter less than or equal to 10 micrometers in diameter [PM_{10}]) and have strict limits on emissions for these pollutants (see Section C.3.2). On October 30, 1994, DOE, after notifying EPA, ceased to monitor criteria air pollutants at the WIPP Ambient Air Monitoring Station because there was no longer a regulatory requirement to do so. TSP monitoring continues weekly at off-site locations.

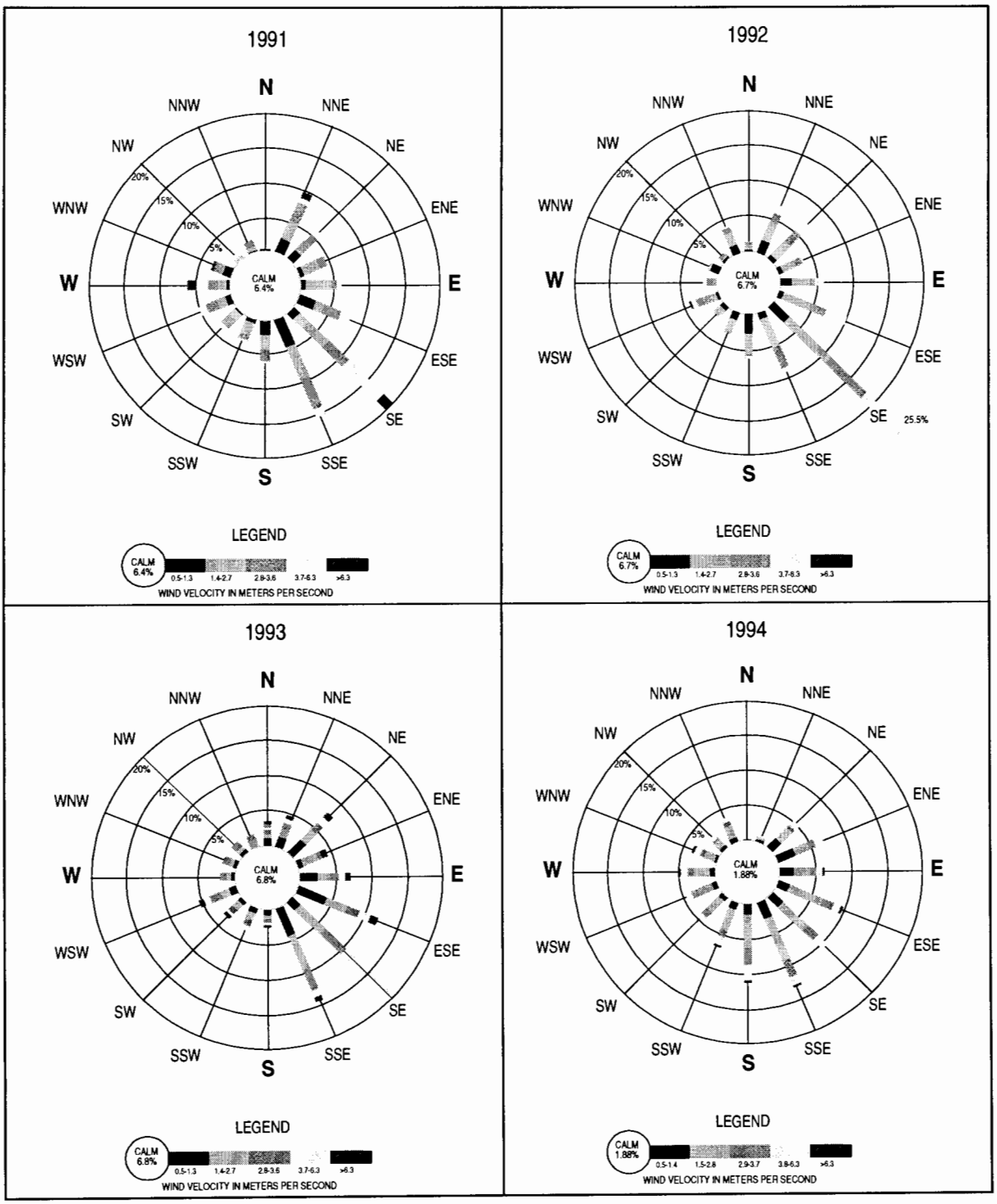
In 1991, after the EPA determined that air migration of VOC's would be a potential concern during testing at the facility, the VOC monitoring program was established at WIPP, and five VOC sampling stations were installed. The VOC monitoring program consisted of monitoring the air pulled from the exhaust shaft for any VOCs released from the test wastes. Samples were regularly analyzed for five target VOCs (carbon tetrachloride, methylene chloride, trichloroethylene, trichloroethane, and freon-113), and for other organics that might be detected.

Background monitoring of target VOCs will continue at three of the five locations. One location will measure the target compounds in the exhaust stream near the top of the exhaust shaft, another will sample the ambient air drawn into the underground facility, and the third will measure the background concentration. By measuring VOCs at the three locations it will be possible to define the variability in VOC concentration due to WIPP operations.

The regional climate is semiarid, with low precipitation and humidity and a high rate of evaporation. Precipitation is unevenly distributed throughout the year, with most occurring during summer thunderstorms. Winds are mostly from the southeast and moderate. In late winter and spring, there are strong west winds and dust storms. Thunderstorms are frequent from June through September, and are often accompanied by hail. Rains are brief but occasionally intense and can result in flash flooding in arroyos and along floodplains. Tornadoes are common throughout the region. From 1955 through 1967, 15 tornadoes were reported in the WIPP site area covered by one degree of latitude and longitude (DOE 1980).

The Carlsbad Air Terminal is the closest meteorological monitoring station and is located approximately 50 kilometers (30 miles) west of WIPP. Because of the relatively flat terrain, meteorological measurements at the airport are considered to be representative of the region. The mean annual temperature is 16 degrees Celsius (60 degrees Fahrenheit), and the mean annual precipitation is about 33 centimeters (13 inches). Drought conditions occurred during 1994. Precipitation for the 1994 calendar year was 31 percent less than that of the 1993 calendar year and 74 percent less than that of the 1992 calendar year.

The predominant wind direction at WIPP during calendar years 1991 through 1993 was from the southeast. However, during the 1994 calendar year, winds during late spring were primarily from the west. Wind speeds categorized as calm (less than 0.5 meters [1.6 feet] per second) usually occur about 7 percent of the time. Wind speeds of 1.4 through 2.7 meters (4.6 through 8.9 feet) per second were the most prevalent in the 1994 calendar year, occurring 25.5 percent of the time. Figure 4-3 displays the 1991 through 1994 wind roses (DOE 1992, 1993b, 1994a, and 1995f). These conditions are consistent with long-term averages for the region. For a comprehensive



Source: DOE 1992, 1993b, 1994, and 1995f

Figure 4-3
Windroses for 1991-1994

discussion of climatology at the WIPP site, see Section 7.1.1 of the FEIS (DOE 1980). The WIPP site annual environmental reports provide (DOE 1991, 1992, 1993b, 1994a, and 1995f) monthly and annual temperatures, precipitation, and wind conditions.

The ambient noise level in the WIPP area prior to construction was 26 to 28 decibels (DOE 1980). DOE requires its facilities to comply with Occupation Safety and Health Administration standards as promulgated in Title 29, of the Code of Federal Regulations (CFR), Part 1910.95. Any WIPP noise sources with the potential to exceed these standards have been mitigated (for example, noise dampers have been installed in the underground air exhausts) and are now in compliance with 29 CFR Part 1910.95.

KEY ELEMENTS CONCERNING GEOLOGY AND HYDROLOGY

Since publication of SEIS-I, additional studies and analyses have provided new information regarding geology and hydrology. These studies have improved the understanding of processes considered in evaluating long-term performance. Several examples are listed below:

- Extensive testing of the Salado Formation's saltbeds and interbeds has resulted in confirmation of the Salado's extremely low permeability.
- Recent test data have enabled improved predictions of pressures at which Salado interbeds will likely fracture and relieve elevated gas pressures within the repository.
- Refined modeling of gas generation suggests that elevated gas pressure may slow down or stop brine inflow, thereby slowing gas-generating processes.
- Geophysical surveys indicate that pressurized brine reservoirs in the Castile Formation occur as three or four discrete pockets.
- Three-dimensional modeling of groundwater flow in the Rustler Formation suggests a very small amount of vertical flow and a preponderance of horizontal flow within the Culebra Dolomite.
- Recent tests on the Culebra Dolomite will provide new data on contaminant transport in the Culebra and on the Culebra's potential to retard radionuclides.

4.1.3 Geology and Hydrology

The first part of this section summarizes the geological and hydrological features of the WIPP site as well as key factors relevant to the repository's ability to isolate waste (repository performance). The remainder provides a discussion of what has been learned since SEIS-I. For the interested reader, there are several WIPP documents containing detailed, comprehensive, and technical descriptions of WIPP geology and hydrology. These documents have been incorporated by reference. Among them are FEIS (DOE 1980), SEIS-I (DOE 1990), the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* done by Sandia National Laboratories (SNL) (SNL 1992), the *Draft No-Migration Variance Petition* (DOE 1995c), the *Waste Isolation Pilot Plant Safety Analysis Report* (DOE 1995l), the *Draft Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE 1995a), and the *Draft Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant, July 1995 Update* (DOE 1995g). These references are cited throughout this section.

The geophysical, geochemical, and hydrological behavior of various strata believed to be important to WIPP performance has been investigated during almost 20 years as a part of the WIPP program. Since SEIS-I, most of the research performed has centered on improving understanding of groundwater flow and transport processes. This research has primarily dealt with: (1) hydraulic testing of the Salado Formation and characterization of brine flow within the Salado; (2) modeling

of the interactions among gas generation, brine flow into the repository, and contaminated brine flow out of the repository; (3) modeling of regional groundwater flow in units above and below the Salado, particularly the Rustler Formation, which overlies the Salado and includes the Culebra Dolomite; (4) hydraulic testing and tracer testing within the Culebra Dolomite; (5) characterization and modeling of hydrologic and geochemical characteristics of the Culebra; and (6) geophysical characterization of the pressurized brine occurrences in the Castile Formation that underlies the Salado. The following section summarizes results of investigations of WIPP geology and hydrology published since SEIS-I.

4.1.3.1 Geology

No substantive changes have occurred in the understanding of the site and regional geology since SEIS-I. A brief description of surface and subsurface geology and seismicity, both at the WIPP site and the region immediately surrounding the WIPP repository, is presented here. For detailed descriptions, see the references listed above.

Regional Setting and Surface Geology

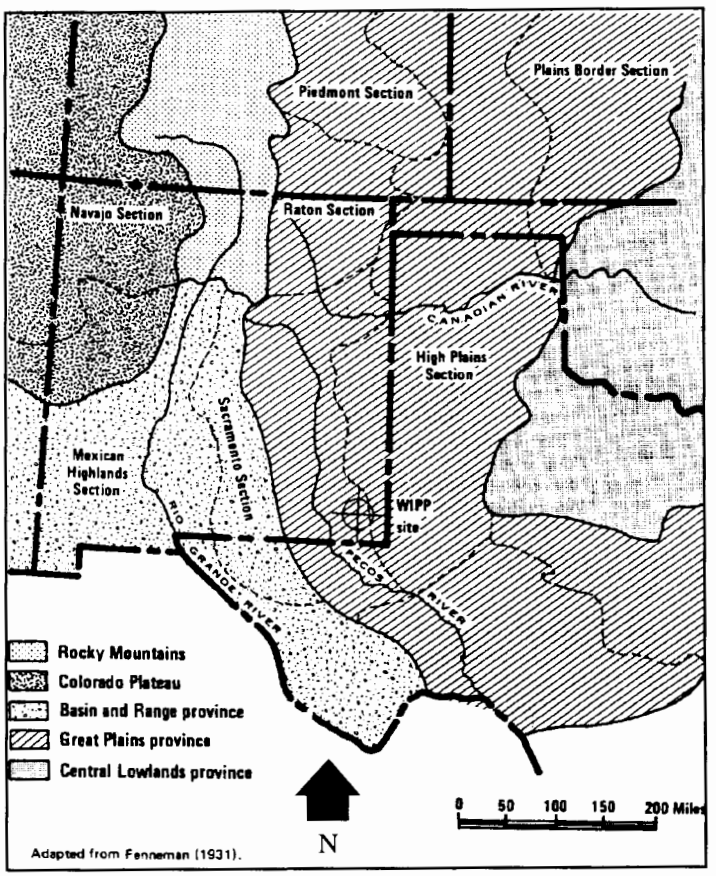
WIPP is located in southeastern New Mexico, in the Pecos Valley Section of the Great Plains Physiographic Province. The terrain throughout the province varies from plains and lowlands to rugged canyons. In the immediate vicinity of WIPP, numerous small mounds formed by wind-blown sand characterize the land surface. A layer enriched in calcium carbonate material, the Mescalero caliche, is typically present beneath the surface layer of sand. This caliche ranges in age from about 510,000 years at the base of the layer to about 410,000 years in the upper part, based on samples within the layer (Axness et al. 1995). The caliche layer overlies a 600,000-year old volcanic ash layer (Axness et al. 1995). The Mescalero caliche can be found over large portions of the Pecos River drainage area and is generally considered to be an indicator of surface stability (DOE 1980). The site slopes gently from east to west, from an elevation of 1,088 meters (3,570 feet) above sea level at its eastern boundary to 990 meters (3,250 feet) above sea level along its western boundary.

A high plains desert environment characterizes the area. Due to the seasonal nature of the rainfall, most surface drainage is intermittent. The Pecos River, 20 kilometers (12 miles) southwest of the WIPP boundary, is a perennial river and the master drainage for the region. A natural divide lies between the Pecos River and WIPP. As a result, the Pecos drainage system does not currently affect the site. Local physiographic features include Nash Draw and the San Simon Swale (see Figure 4-4).

Subsurface Geology

WIPP is located in the northern portion of the Delaware Basin, a structural basin underlying present-day southeastern New Mexico and western Texas and containing a thick sequence of sandstones, shales, carbonates, and evaporites. The references listed above describe basic characteristics of the stratigraphy (sequence of rock units) of the Delaware Basin. Major tectonic activity (movements of the earth's crust) associated with the development of the Delaware Basin ended over 250 million years ago, and the WIPP site has been geologically stable ever since.

The WIPP repository is located at a depth of approximately 655 meters (2,150 feet) in rocks of Permian age. The sediments accumulated during the Permian period represent the thickest portion



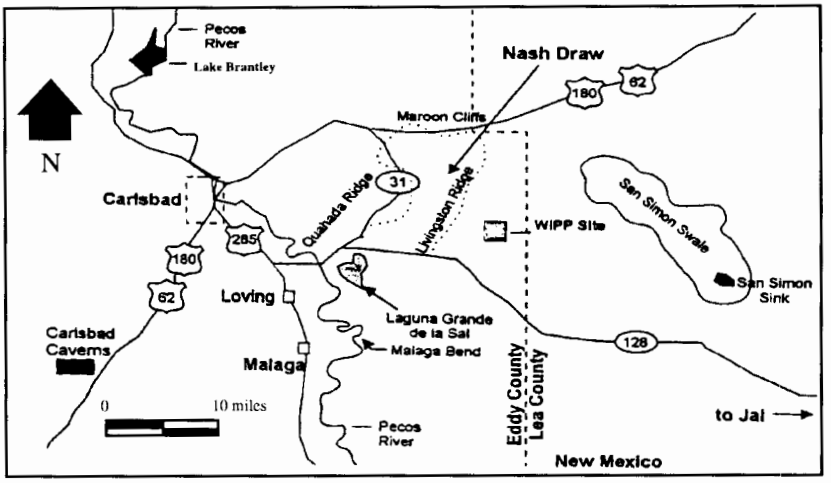


Figure 4-4
WIPP Site Location in Southeastern New Mexico

of the sequence in the northern Delaware Basin and are divided into four series. From oldest to youngest, these series are: the Wolfcampian, Leonardian, Guadalupian, and Ochoan. As shown in Figure 4-5, the Ochoan series is divided into four formations. From oldest to youngest, these formations are: Castile, Salado (the lower part of which contains the WIPP repository), Rustler, and Dewey Lake.

The discussion below presents the geologic formations important to understanding the long-term performance of WIPP, including: the host rock for the WIPP repository (the Salado Formation); the formations below the Salado (the Castile and Bell Canyon Formations); and the formations above the Salado (the Rustler and Dewey Lake Formations).

Salado Formation

The Salado Formation is a massive bedded salt formation, predominantly halite (sodium chloride), and is thick and laterally extensive. DOE selected the Salado Formation as the site of the WIPP repository for several geologic reasons (DOE 1980, 1990): (1) the Salado halite units have very low permeability to fluid flow, which impedes groundwater flow into and out of the repository; (2) the Salado is regionally widespread; (3) the Salado includes continuous halite beds without complicated structure; (4) the Salado is deep with little potential for dissolution, (5) the Salado is near enough to the surface that access is reasonable; and (6) the Salado is largely free of mobile groundwater, as compared to existing mines and other potential repository sites.

The Salado Formation is approximately 530 to 610 meters (1,740 to 2,000 feet) thick in the WIPP site area, and the repository is located in the thickest part. The Salado is comprised of three members. From oldest to youngest, these are: the Lower Member, the McNutt Potash Member, and the Upper Member. The WIPP repository is located in the Lower Member. The Salado contains many distinctive and laterally continuous layers composed mostly of anhydrite (a calcium sulfate mineral) and polyhalite (a potassium-magnesium-calcium sulfate mineral). These layers are so continuous that they have been used by geologists as "marker beds" (MB) and numbered to designate vertical position within the Salado Formation. The WIPP repository is located between MB 139 and MB 138.

Castile Formation

The Castile Formation directly underlies the Salado Formation and comprises the base of the Ochoan Series (see Figure 4-5). It is found 244 meters (800 feet) below the level of the repository. The Castile Formation near WIPP typically contains three relatively thick anhydrite/carbonate units and two thick halite units. The thickness of the Castile varies regionally as well as locally beneath WIPP, and there is considerable evidence from borehole data and geophysical surveys that the units of the Castile are deformed. The more brittle anhydrite units of the Castile are probably fractured, and the fracture zones are relatively permeable and act as zones for accumulation of brine originating in the Castile (DOE 1995l). The Castile is exposed at the surface over a considerable area along the western side of the Delaware Basin. In the eastern part of the basin, it is approximately 430 to 460 meters (1,400 to 1,500 feet) thick. At the northern boundary of WIPP, the Castile's thickness has been measured at 301 meters (989 feet).

Bell Canyon Formation

The Bell Canyon Formation underlies the Castile Formation and is the uppermost formation of the Guadalupian Series (see Figure 4-5). Near WIPP, the Bell Canyon is comprised of a layered

SYSTEM	SERIES	GROUP	FORMATION	MEMBER	DEPTH AT WIPP WASTE SHAFT meters (feet)
RECENT	RECENT		SURFICIAL DEPOSITS		
QUATER-NARY	PLEISTO-CENE		MESCALERO CALICHE		
			GATUNA		
TRIASSIC		DOCKUM	SANTA ROSA		30 (97)
PERMIAN	OCHOAN		DEWEY LAKE		164 (538)
			RUSTLER	Forty-niner	182 (596)
				Magenta Dolomite	189 (621)
				Tamarisk	215 (707)
				Culebra Dolomite	222 (729)
				lower unnamed	257 (844)
			SALADO	upper	409 (1,343)
				McNutt Potash	526 (1,727)
				lower WIPP	655 (2,150)
					~810 (2,650)
			CASTILE		~1,200 (4,000)
	GUADALUPIAN	DELAWARE MOUNTAIN	BELL CANYON		~1,550 (5,100)
			CHERRY CANYON		~1,900 (6,200)
			BRUSHY CANYON		

Figure 4-5
Regional Geologic Column

sequence of sandstones, shales, siltstones, and limestones approximately 300 meters (1,000 feet) or more in thickness. It is the uppermost target of hydrocarbon exploration in the local area and is known from outcrops on the west side of the Delaware Basin and from oil and gas exploration boreholes (DOE 1996b).

Rustler Formation

The Rustler Formation directly overlies the Salado Formation and contains five members (see Figure 4-5). From the base of the Rustler, these members are: the unnamed lower Member, the Culebra Dolomite, the Tamarisk, the Magenta Dolomite, and the Forty-niner. The Culebra and Magenta Dolomites are gypsum-bearing dolomites containing numerous cavities (vugs), fractures, and silty zones. The other three members contain various amounts of anhydrite, siltstone, claystone, and halite. The Rustler is the youngest (uppermost) formation in the Delaware Basin and primarily contains evaporite deposits. In the WIPP region, the Rustler can be 152 meters (500 feet) thick, although it ranges from 91 to 107 meters (300 to 350 feet) thick within the WIPP boundary.

Dewey Lake Formation

The Dewey Lake Formation overlies the Rustler Formation at WIPP (see Figure 4-5). Consisting largely of reddish-brown siltstones and claystones with lesser amounts of sandstone, the Dewey Lake Formation is about 30 to 170 meters (100 to 560 feet) thick in the vicinity of WIPP.

Santa Rosa Formation

The Santa Rosa Formation (Axness et al. 1995), also called the Dockum Group, ovelies the Dewey Lake Formation. Characterized by light reddish-brown sandstones and conglomerates, the Santa Rosa Formation is thin to absent within the WIPP site boundaries, but is thicker (78 meters [255 feet] or greater) to the east (Axness et al. 1995).

Gatuña Formation

The Gatuña Formation overlies the Santa Rosa Formation and is somewhat similar in lithology and color, although the Gatuña is characterized by a wide range of lithologies (coarse conglomerates to gypsum-bearing claystones). The Gatuña is Pleistocene in age, based on the 600,000-year old volcanic ash layer in the Upper Gatuña (DOE 1996b). This is the same ash layer used to determine the upper age limit of the Mescalero Caliche that overlies the Gatuña Formation.

Faulting and Seismicity

Understanding of the regional seismicity has changed little since SEIS-I. No surface displacement or faulting younger than early Permian (Wolfcampian) has been reported, indicating that tectonic movement since then, if any, has not been noteworthy. No mapped Quaternary (last 1.9 million years) or Holocene (last 10,000 years) faults exist closer to the site than the western escarpment of the Guadalupe Mountains, about 100 kilometers (60 miles) west-southwest (DOE 1995l).

The strongest earthquake on record within 290 kilometers (180 miles) of the site was the Valentine, Texas, earthquake of August 16, 1931 (DOE 1995l), with an estimated Richter magnitude of 6.4. A Modified Mercalli Intensity V was estimated for this earthquake's groundshaking at WIPP. At Intensity V, groundshaking is felt by nearly everyone, few instances of cracked plaster occur, and

unstable objects are overturned. This is the strongest groundshaking intensity known for the WIPP site. This and other regional earthquakes are shown on Figure 4-6.

Since 1990, at least two seismic events have occurred that were recorded at WIPP. The Rattlesnake Canyon Earthquake occurred approximately 100 kilometers (60 miles) east-southeast of WIPP in January 1992. This event was assigned a Richter magnitude of 5.0 and occurred at a depth of approximately 12 kilometers (7.4 miles). This event had no effect on any of the structures at WIPP, as documented by post-event inspections by WIPP staff and the New Mexico Environment Department (DOE 1995l).

The most recent earthquake recorded at the WIPP site occurred on April 14, 1995, and was located 32 kilometers (20 miles) east-southeast of Alpine, Texas (approximately 240 kilometers [150 miles] south of the site). It was assigned a magnitude of 5.3 and is the largest event within 300 kilometers (185 miles) of the site since the Valentine, Texas, earthquake (Sanford et al. 1995). This event also had no effect on any structures at WIPP.

Based on a probabilistic seismic risk analysis and the region's historic seismicity, the strongest earthquake acceleration expected at WIPP would be 0.075 gravity (7.5 percent of acceleration due to gravity) with an average return period of 1,000 years. The design-basis earthquake (DBE) is conservatively assumed to be 0.1 gravity. Mine experience and studies on earthquake damage to underground facilities show that tunnels, mines, and wells are not damaged at sites having peak surface accelerations below 0.2 gravity (DOE 1995l).

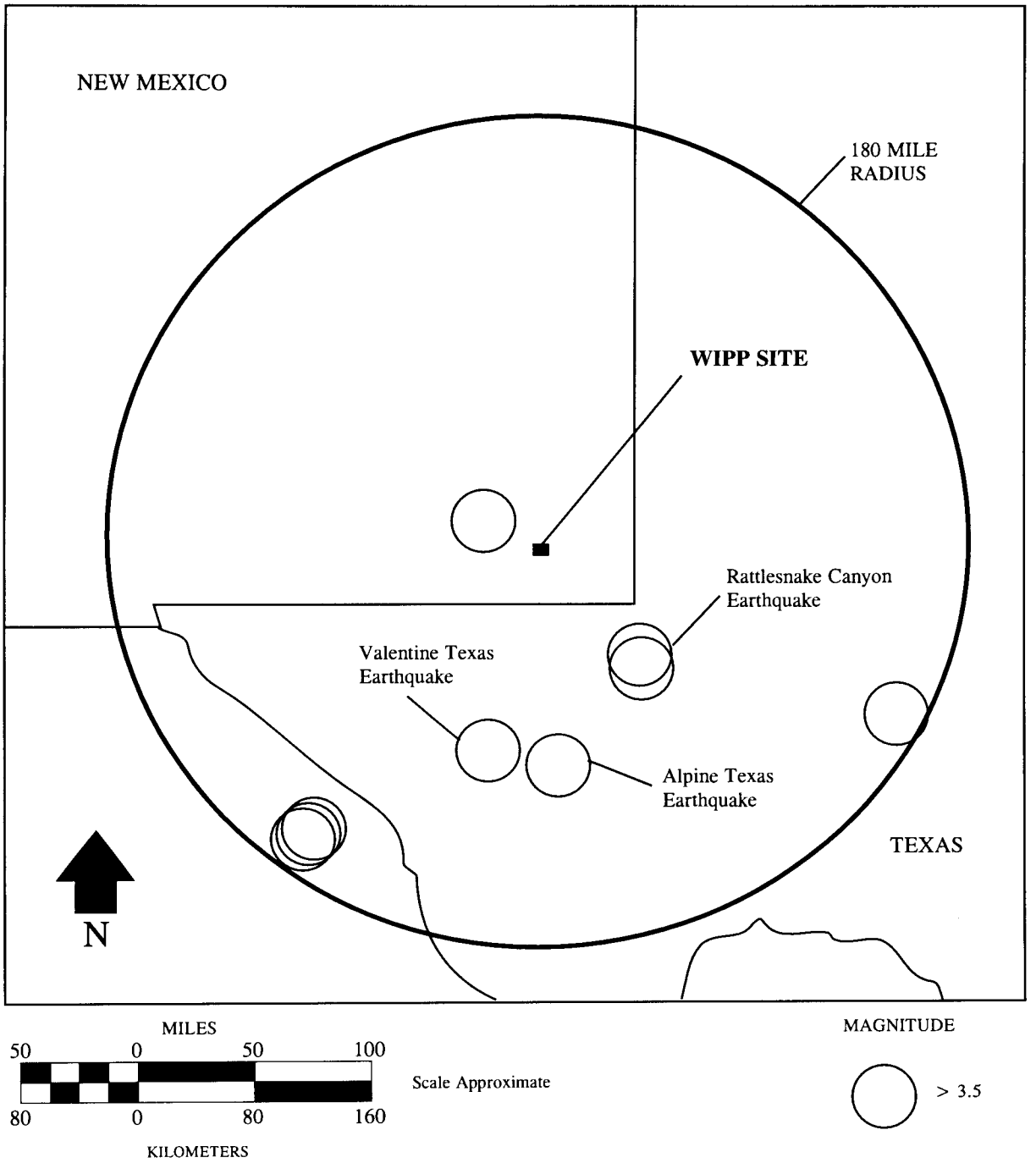
Natural Resource Exploration and Development

Hydrocarbons

Prior to 1970, most commercially-related drilling in the WIPP area targeted shallow oil (1,200 to 1,400 meters [4,000 to 4,500 feet] in depth) in the Bell Canyon Formation. Most of the exploratory wells from this period were plugged and abandoned. From 1970 to the mid-1980s, most drilling near WIPP focused on gas exploration in the deeper Morrow and Atoka Formations (approximately 4,000 meters [13,000 feet]). Most drilling for deep gas occurred northeast of WIPP. After parts of the Potash Area were opened to oil and gas exploration in the 1990s, exploration for deep gas in the Morrow and Atoka Formations occurred along the western boundary of the WIPP land withdrawal area (Broadhead et al. 1995).

During the late 1980s and early 1990s, commercial oil was discovered in the Cherry Canyon and Brushy Canyon Formations of the Delaware Mountain Group adjacent to the eastern and northeastern boundary of WIPP, at a depth of approximately 2,100 to 2,400 meters (7,000 to 8,000 feet). These formations are currently the primary exploration and development targets in the Permian Basin, one of the most actively explored areas in the United States (Broadhead et al. 1995).

Three commercial wells have been drilled for oil and gas within the boundaries of the WIPP land withdrawal area. Two vertical wells were drilled within the area during the 1970s; neither one became a producing well. A third well was drilled in 1982 from a location outside of the WIPP



NOTES:

LOCATIONS OF SELECTED EARTHQUAKES WITHIN 300 KILOMETERS (180 MILES) OF THE WIPP SITE. FOR DRAFTING CLARITY NO EARTHQUAKE WITH A MAGNITUDE LESS THAN 3.5 IS SHOWN.

Figure 4-6
Regional Earthquake Epicenters Occurring after 1962

land withdrawal area. The well was drilled at an angle underneath the area to intercept gas in the Atoka Formation and is currently commercially productive (Broadhead et al. 1995).

Potash

Bedded potash was discovered in Eddy County, New Mexico, in 1925. By 1944, New Mexico was the largest domestic potash producer, representing 85 percent of consumption (Barker and Austin 1995). Development continued through the 1950s and 1960s, reversed in the 1970s and, for several reasons has declined since (Barker and Austin 1995).

The Carlsbad Potash District, located in southeastern New Mexico near the northeastern border of the Delaware Basin, contains the largest domestic potash reserves. The only potash mines in the state are located in Eddy and Lea Counties within the soluble potash zone. The WIPP land withdrawal area occupies approximately 41 square kilometers (16 square miles) on the southeastern edge of the Known Potash Leasing Area (or Potash Enclave, administered by BLM). During the last decade or so, commercial potash mining has continued and the mining front is much closer to the WIPP site, having approached the site boundary on the southwestern side. Future mining is likely to occur there or on the north side of the site (Barker and Austin 1995).

4.1.3.2 Hydrology

This section provides a summary of the surface hydrology of the WIPP region, followed by the hydraulic and hydrogeologic characteristics of the geologic formations relevant to WIPP.

Surface Water Hydrology

Understanding of the surface water hydrology in the WIPP vicinity has changed little since SEIS-I. WIPP is located east of the Pecos River and within the Pecos River basin (which represents about one-half of the drainage area of the Rio Grande Water Resources Region). The drainage area of the Pecos River at this location is 49,200 square kilometers (19,000 square miles). The WIPP site has a few small intermittent creeks, the only westward-flowing tributaries of the Pecos River within 32 kilometers (20 miles) north or south of the site.

The Pecos River is the main surface water resource in the WIPP vicinity. Due to inflow from brine springs (from the Rustler Formation) and slight exceedence of water quality levels of certain heavy metals (DOE 1996b), river water is not used for human consumption. Irrigation and livestock watering are the primary uses of the water from the Pecos.

More than 90 percent of the mean annual precipitation at the site is lost by evapotranspiration. On a mean monthly basis, evapotranspiration at the site greatly exceeds the available rainfall; however, intense local thunderstorms produce runoff and percolation. The maximum recorded flood on the Pecos River occurred on August 23, 1966, near Malaga, about 25 kilometers (15 miles) from WIPP. The maximum elevation of the flood was 90 meters (300 feet) below the elevation of the WIPP surface facility.

Groundwater Hydrology

The WIPP repository is situated in the thick, relatively impermeable Salado Formation saltbeds 655 meters (2,150 feet) below the ground surface. The hydrologic and mechanical properties of the saltbeds surrounding WIPP are better understood than the regional hydrology. Generally,

however, groundwater in the Rustler and Dewey Lake Formations and the units overlying them are essentially isolated from the hydrology of the Salado Formation.

The Rustler Formation includes the Culebra and Magenta Dolomites, two units containing water of low quality (brine to brackish) (Axness et al. 1995). The Culebra Dolomite, which is the first notable water-bearing unit above the Salado Formation, has been investigated for its potential to transport radionuclides released from the repository resulting from a borehole intrusion. Groundwater flow in the units overlying the Salado Formation has been assumed to occur primarily in the Culebra Dolomite, although it is recognized that regional flow in the Rustler Formation is three-dimensional and occurs to some degree in all Rustler units (Axness et al. 1995). Flow in the Culebra is generally from north to south. The Dewey Lake Formation overlies the Rustler Formation and in some areas is relatively transmissive, particularly in the south central and southwestern part of the WIPP site (Axness et al. 1995). The location of the water table is generally considered to be the Dewey Lake.

Only a few locations of groundwater recharge and discharge to and from the Rustler Formation are known. The only documented areas of naturally occurring groundwater discharge in the vicinity of WIPP are the Pecos River near Malaga Bend (Hunter 1985) and, to a lesser extent, the saline lakes in Nash Draw. This local flow associated with Nash Draw is unrelated to groundwater flow at WIPP. The only documented area of groundwater recharge is also near Malaga Bend (Hunter 1985). This location is hydraulically downgradient from the repository, and recharge here has little relevance to flow near WIPP. Recharge from the surface probably occurs 15 to 30 kilometers (10 to 20 miles) northwest of WIPP, where the Rustler Formation reaches the surface. An undetermined amount of inflow may also occur as leakage from overlying units throughout the region.

The following sections discuss the hydraulic and hydrogeologic characteristics of the geologic formations enclosing, underlying, and overlying the WIPP underground facility.

Salado Formation Hydrology

As described above, the Salado Formation has several characteristics which make it a favorable host medium for a repository, including its low permeability to fluids and its relatively low water content. Hydraulic tests from which permeabilities have been derived indicate that the Salado halite has either extremely low or no permeability (no measurable flow occurred during some of the tests). Tests in pure halite indicate permeabilities of less than 1×10^{-23} square meters (1×10^{-22} square feet); permeabilities measured in impure halite range from 1×10^{-23} to 4×10^{-18} square meters (1×10^{-22} to 4×10^{-17} square feet) (Axness et al. 1995).

There is also indirect evidence of the Salado's low permeability. Measurements in the Salado in the WIPP site region have shown that there are areas of anomalously high and low fluid pressures. If the Salado were relatively permeable, these pressures would likely have equalized relatively quickly; conversely, if the Salado were relatively impermeable, these pressures would probably not equalize, or would do so only over a very long time. Since these pressure differences do exist, it is likely that these areas of anomalous pressures have remained constant over long periods of time because of the relative lack of permeability of the salt (Lappin et al. 1989).

Inflow of brine into the repository excavation has been observed in boreholes and from "weeps," which are localized brine seeps issuing from cracks in the disturbed surfaces of the repository walls, floors, and roofs. The volumes of brine observed from these occurrences have been small,

and flow into the repository has ceased within three years of initial observation (Howarth et al. 1995). Brine migrates along clay-rich layers and cracks developed in the "disturbed rock zone" (DRZ). Eventually the DRZ heals, thereby cutting off fracture-controlled flow paths into the repository. Nevertheless, for the long-term, it is reasonable and conservative to consider that there may be brine near the repository that would flow toward and into the repository, albeit at a low rate.

Models are available to estimate the amount of brine that would flow into the excavation over time. Howarth et al. (1995) discussed three mechanisms of brine inflow: (1) far-field flow, which is flow from outside the influence of the repository along naturally interconnected pore spaces; (2) redistribution, which is flow within the interconnected fractures of the DRZ; and (3) clay consolidation, which is the squeezing of water out of clay layers which intersect the repository. Of these mechanisms, only the first two are considered crucial (Howarth et al. 1995); together, they are capable of contributing approximately 50 to 160 cubic meters (1,785 to 5,712 cubic feet) of brine per disposal room, which has an approximate volume of 3,675 cubic meters (128,700 cubic feet) (Howarth et al. 1995).

Brine inflow is a concern in that the brine would provide necessary moisture for the degradation of certain waste material components and gas generation. This could occur from a combination of processes such as microbial activity, canister corrosion, corrosion of metal waste, and radiolysis of brine. If a sufficient supply of brine exists and gas accumulates faster than it can dissipate, it is conceivable that gas pressure could build up to the point that it exceeds lithostatic pressure (approximately 15 million pascals). In this event, fractures would form in the repository walls and provide pathways for contaminants away from the repository. It is likely that fractures, if formed, would do so within and along the more brittle anhydrite beds near the excavation, such as MB 139.

The Salado salt has such a low permeability that it is difficult to measure with existing technology. Studies of the Salado indicate that the impure halite (greater than 0.5 percent impurities) may exhibit brine flow through pore spaces and along grain boundaries, but measurements on continuous layers of pure halite indicate zero or near-zero permeabilities. The interpretation of flow mechanism is inconclusive. The presence of the pure halite layers suggests that vertical flow through the Salado does not occur. In any case, the assumption of Darcy flow within the Salado is conservative, because the flow models use the properties of the most permeable layers for the entire formation (Howarth et al. 1995).

Castile Formation Hydrology

Two boreholes drilled into the Castile Formation have encountered pockets of pressurized brine that are important in evaluating the scenarios for inadvertent intrusion of the WIPP repository. One of the boreholes is located within the WIPP boundary; the second borehole is located approximately 3.2 kilometers (2 miles) northeast of the northern boundary. Hydraulic tests performed in both boreholes show that such brine occurrences, which are found only in fractured permeable regions of the Castile anhydrite, are localized in extent. Testing of the pressurized brine occurrences encountered by boreholes ERDA-6 and WIPP-12 led to the conclusion that most of the brine is stored in low-permeability microfractures and that only about five percent of the brine is in large open fractures (Lappin et al. 1989). Chemical analyses of the brine indicate that it is saturated with respect to salt (sodium chloride), or nearly so, and therefore has little or no ability to dissolve salt. In any case, it has been estimated that Castile brine pockets have been isolated for as long as one million years (Lappin et al. 1989). Thus, unless penetrated by a subsequent borehole, they are likely to remain isolated.

Based on the identification of a conducting zone defined by time-domain electromagnetic surveys (TDEM, a geophysical technique), current conceptual models of the Castile now incorporate four distinct brine reservoirs beneath different parts of the WIPP repository (Axness et al. 1995). In SEIS-I, DOE assumed brine to be present everywhere beneath the waste-emplacement panels.

Bell Canyon Formation Hydrology

The Bell Canyon Formation is considered to form a single hydrostratigraphic unit about 300 meters (1,000 feet) thick. The low-permeability of the Castile Formation that overlies it effectively isolates the fluid flow in the Bell Canyon. In the WIPP vicinity, the brines in the Bell Canyon flow northeasterly and discharge into the Capitan aquifer (DOE 1996b).

Rustler Formation Hydrology

Since 1990, seven additional locations have been drilled to investigate the Rustler Formation. Hydrologic testing has been recently completed at Pad H-19; the final report has not yet been issued.

The Rustler Formation has been actively investigated over the years, because it contains the first laterally continuous hydrologic unit above the Salado Formation, the Culebra Dolomite. It has also been considered a potential pathway for a release from the repository to the accessible environment. The Culebra exhibits wide ranges in hydraulic properties, local flow and transport mechanisms, and geochemistry.

Culebra hydraulic properties have been tested in the field at 41 locations in the WIPP vicinity (Axness et al. 1995). Transmissivity values in the Culebra vary by six orders of magnitude across the WIPP site (Lappin et al. 1989). In general, the highest transmissivities (approximately 0.01 square meters [0.1 square feet] per second) are found in areas where no halite is found in the Rustler, and the lowest transmissivities (4×10^{-9} square meters [4.3×10^{-8} square feet] per second) are found where the three non-dolomite Rustler members contain halite. Further, transmissivities of about 1×10^{-6} square meters (1.08×10^{-5} square feet) per second or greater appear to be associated with fracturing. Where transmissivities range from 1×10^{-6} to 1×10^{-4} square meters (1×10^{-5} to 1×10^{-3} square feet) per second, open fractures are present in the core. Where transmissivities are greater than 1×10^{-4} square meters (1×10^{-3} square feet) per second, the core is heavily fractured to the point of brecciation (Axness et al. 1995).

Groundwater flow in the Culebra in the vicinity of WIPP is generally to the south, based on analyses of water levels in 35 wells (Axness et al. 1995). Contours of these water levels suggest the following: flow above the WIPP repository is to the south; flow in Nash Draw is to the southwest; and flow south of WIPP is possibly toward the west. Groundwater chemistry along the flow direction is not what would be predicted, based on common flow-chemistry relationships. Total dissolved solids decrease downgradient, and the general chemical nature changes as well (sodium and chloride at the WIPP site to magnesium, calcium, and sulfate south of the site). The relationship between water chemistry and groundwater flow is not yet resolved (Axness et al. 1995).

The Culebra is recognized as a potential pathway for releases. It also appears that it may be effective in retarding radionuclides, a process in which the radionuclides are temporarily adsorbed on some mineral grains, thereby inhibiting their transport along the pathway. This retardation

potential is based on analysis of flow through both the pore spaces in the dolomite and through the fractures in the unit.

The contact between the Rustler and the Salado Formations in the vicinity of Nash Draw (see Figure 4-4) is of interest, because it can provide evidence of earlier dissolution. Where dissolution of halite has occurred, a residue of gypsum, clay, and sandstone remains (Robinson and Lang 1938). This residue is absent at WIPP. Water in this residue layer contains the largest concentrations of dissolved solids in the area near WIPP and is classified as brine (Mercer 1983).

The Culebra Dolomite is the first continuous, permeable, water-bearing rock unit above the WIPP repository, and it is bounded above and below by relatively impermeable layers. Therefore, SEIS-I (DOE 1990) and SNL performance assessment calculations (SNL 1992) treated it as a confined aquifer. That is, the calculations consider water to flow along and through the Culebra rock layer, with no flow between the Culebra and the over- and underlying rock units.

SNL has conducted three-dimensional modeling of groundwater flow in the Rustler Formation in the context of the groundwater basin for the last few years (Corbet and Wallace 1993, Axness et al. 1995). The modeling results suggest that a very small amount of vertical flow occurs within and across the low-permeability units of the Rustler, and the preponderance of flow is within the Culebra Dolomite.

Dewey Lake Formation Hydrology

Observed losses of circulation fluid during drilling (Mercer 1983, Lappin et al. 1989) suggest a zone of permeability in the Dewey Lake Formation above the WIPP repository level. Indications of a water table in this formation are absent beneath much of the WIPP surface facility, although the formation does contain a saturated zone (possibly perched) in the southwest to south central part of the WIPP site boundary area as well as south of the site (Axness et al. 1995). Axness et al. (1995) (or the study) observed moist but nonsaturated conditions at similar depths north of the saturated zone. A new well located approximately 0.5 kilometer (0.3 mile) southwest of the southwest corner of the waste emplacement panels produced 5.7 to 6.8 cubic meters (1,505 to 1,795 gallons) of water per hour, apparently from the high permeability zone (Axness et al. 1995).

Potential Hydrologic Effects of Natural Resources Activities

The wide range of natural resource-related activities, which historically have been and will continue to be important in the region, have implications for future site impacts. Oil and gas reserves are accessed by drilling through the Salado Formation and into the underlying oil- and gas-bearing formations. Hydrocarbon exploration and development, as a normal part of operations, involves the injection of brine into boreholes for brine disposal and enhanced oil recovery as well as eventual abandonment and plugging of wells. Injected brine may or may not impact the hydrology in the vicinity of the injection well. Further, there have been several incidents of waterflood problems with injected water migrating from adjacent properties through the Salado Formation, and water-level rises in WIPP wells monitoring the Culebra Dolomite Member have been attributed to the influence of a nearby disposal well (Neill et al. 1996).

Potash mining, in addition to requiring brine disposal, may cause weakening and collapse of overlying strata and subsequent subsidence. This may result in the propagation of fractures through the overlying aquifers and potential contaminant pathways (e.g., the Culebra Dolomite),

thereby increasing their hydraulic conductivity and potentially damaging petroleum well casings and uncased wells (Neill et al. 1996).

4.1.4 Biological Resources

SEIS-I (DOE 1990) describes the WIPP site area as characterized by sand dunes. Further, it describes the vegetation as dominated by shinnery oak (*Quercus havardii*), mesquite *(Prosopis grandulosa*), sand sage (*Artemisia filifolia*), dune yucca (*Yucca campestris*), smallhead snakeweed (*Gutierrezia microcephala*), three-awn (*Aristida* spp.), and numerous species of forbs and perennial grasses. The most conspicuous mammals at the site are the black-tailed jack rabbit (*Lepus californicus*) and the desert cottontail (*Sylvilagus auduboni*); other common small mammals include Ord's kangaroo rat (*Dipodomys ordii*), plains pocket mouse (*Perognathus flavescens*), and northern grasshopper mouse (*Onychomys leucogaster*). Large mammals include mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), and coyote (*Canis latrans*). Loggerhead shrike (*Lanis ludovicianus*), Pyrrhuloxia (*Cardinalis sinuata*), and black-throated sparrow (*Amphispiza bilineata*) are common resident birds. The Harris hawk (*Parabuteo unicinctus*) is a resident raptor. Aquatic habitats near WIPP, which include stock watering ponds and tanks, may be frequented by yellow mud turtles (*Kinosternon flarescens*) and tiger salamanders (*Ambystoma tigrinum*) (DOE 1992, 1993b, 1994a, 1995f).

Since SEIS-I, ecological monitoring at WIPP has continued. Changes noted in vegetation distribution include an increase in shrub cover and a decrease in grasses such as black grama grass (*Bouteloua eriopoda)* near the salt tailings (due to the colonization of these habitats by salt-tolerant shrub species). No effects from salt-induced physiological stress were seen on the general vegetation of the area. Changes in cover and density during the last few years have been attributed to variations in annual rainfall (DOE 1993b, 1994a, and 1995f).

Wildlife monitoring has indicated increases in some species of birds at the site. This is primarily due to changes in surface conditions such as water availability (DOE 1992) and to increases in oilfield activities in areas surrounding the site which may have disturbed some populations and caused their relocation within the site (DOE 1994a). Surveys taken from 1984 through 1993 have documented 98 species of birds which inhabit or migrate through the area (DOE 1994a).

Mammal populations have fluctuated as a result of changes in natural conditions such as rainfall, temperature, and disease. No differences in mammal population numbers have occurred as a result of WIPP activities (DOE 1995f).

No threatened or endangered species have been found during surveys on the WIPP site. However, DOE has documented the American peregrine falcon (*Falco peregrinus anatum*) and Aplomado falcon (*Falco femoralis septentrionalis*) outside the site, but within the general area (1994a, 1995f).

In consultation with the USFWS, the Department concluded in SEIS-I that the following threatened

CHANGES IN RARE, THREATENED, AND ENDANGERED SPECIES

The threatened, endangered, and candidate species present in Eddy County, New Mexico, have changed since SEIS-I. In 1995, DOE consulted with the U.S. Fish and Wildlife Service (USFWS), the New Mexico Department of Game and Fish (NMDG&F), and the New Mexico Energy, Minerals and Natural Resources Department (NMEMNR) regarding the presence of federally threatened, endangered, and proposed species, state-listed rare and endangered animals, and state-listed rare and endangered plant species, respectively, in Eddy County, New Mexico. Since SEIS-I, more than 60 new state and federal species have been added to these county-wide lists, although no new species have been found at the WIPP site.

or endangered species occur or have the potential to occur on lands within or outlying the WIPP site: Lee's pincushion cactus (*Coryphantha sneedi* var. *leei*), American peregrine falcon, bald eagle (*Haliaeetus leucocephalus*), and Pecos gambusia (*Notropis simus pecosensis*). DOE stated that it believed the actions described in SEIS-I would have no impacts on any threatened or endangered species because those activities did not involve any ground disturbance that was not already evaluated in the FEIS (DOE 1980). NMDG&F agreed with the Department that the anticipated WIPP activities would probably not have appreciable impacts on state-listed endangered species in the area. The Department concluded in SEIS-I that there is no critical habitat for terrestrial species identified as endangered by either the USFWS or the NMDG&F at the site (DOE 1990).

In September 1995, DOE contacted the USFWS to determine the occurrence of threatened, endangered, and proposed species at WIPP. The USFWS listed eight endangered, six threatened, and 37 proposed species for Eddy County, New Mexico (USFWS 1995) (see Table 4-1). At that time, DOE also contacted the NMDG&F and NMEMNR regarding the occurrence of state-listed rare, threatened, and endangered plant and animal species in Eddy County. The NMDG&F currently lists 22 threatened and 7 endangered animal species (NMDG&F 1995), and the NMEMNR lists 7 state-endangered and 17 state-sensitive plant species (Sivinski and Lightfoot 1995) (see Table 4-1). The number of species of special concern at WIPP are fewer than those listed for the entire county. There is no designated critical habitat for such species at the WIPP site (NMDG&F 1995, USFWS 1995).

To investigate the potential for impact to rare, threatened, endangered, or sensitive plant or animal species as a result of the potential actions presented in the *Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II), a survey of the land that would be affected by WIPP disposal activities at the site is being conducted to identify the occurrence of, or suitable habitat for, these species. The results of this biological survey will be reported to the agencies identified above, considered in the analysis of alternatives, and incorporated into the Final SEIS-II.

4.1.5 Cultural Resources

This section provides a brief evaluation of recent activities concerning the prehistoric and historic cultural resources at WIPP. FEIS (DOE 1980) summarized background discussions and data, followed by an update in SEIS-I (DOE 1990). More recent summaries of the WIPP cultural resources information are found in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1993a) and the *Waste Isolation Pilot Plant Site Environmental Report for Calendar Year 1994* (DOE 1995f).

Cultural resources investigations at WIPP began in 1976 and have continued to the present. A review of the bibliography of existent WIPP cultural resources reports indicates that at least 24 separate investigations have been conducted. SEIS-I summarized two archeological investigations that provide further insight into the life of the hunter-gatherers who occupied the area of the WIPP site.

CHANGES IN CULTURAL RESOURCES MANAGEMENT

Memorandum of Understanding - In 1994, a memorandum of understanding between DOE and the Department of the Interior transferred management responsibility for cultural resources in the Land Withdrawal Area to DOE.

Table 4-1
Species of Special Concern in Eddy County, New Mexico[a]

Name	FE[b]	FT[c]	FC[d]	SE[e]	ST[f]	SR[g]
Mammals						
Arizona black-tailed prairie dog (*Cynomys ludovicianus arizonensis*)			X			
Big free-tailed bat (*Nyctinomops macrotis*)			X			
Black-footed ferret (*Mustela nigripes*)	X					
Cave myotis (*Myotis velifer*)			X			
Fringed myotis (*Myotis thysanodes*)			X			
Gray-footed chipmunk (*Tamias canipes*)			X			
Guadalupe southern pocket gopher (*Thomomys umbrinus guadalupensis*)			X			
Long-legged myotis (*Myotis volans*)			X			
Occult little brown bat (*Myotis lucifugus occultus*)			X			
Pale Townsend's big-eared bat (*Plecotus townsendii pallescens*)			X			
Pecos river muskrat (*Ondatra zibethicus ripensis*)			X			
Small-footed myotis (*Myotis ciliolabrum*)			X			
Swift fox (*Vulpes velox*)			X			
Yuma myotis (*Myotis yumanensis*)			X			
Birds						
American peregrine falcon (*Falco peregrinus anatum*)	X			X		
Arctic peregrine falcon (*Falco peregrinus tundrius*)		X				
Baird's sparrow (*Ammodramus bairdii*)			X		X	
Bald eagle (*Haliaeetus leucocephalus*)		X			X	
Bell's vireo (*Vireo bellii arizonae*)					X	
Black tern (*Chlidonias niger*)			X			
Broad-billed hummingbird (*Cynanthus latirostris*)					X	
Brown pelican (*Pelecanus occidentalis*)	X			X		
Common ground-dove (*Columbina passerina*)				X		
Ferruginous hawk (*Buteo regalis*)			X			
Gray vireo (*Vireo vicinior*)					X	
Interior least tern (*Sterna antillarum*)	X			X		
Loggerhead shrike (*Lanius ludovicianus*)			X			
Mexican spotted owl (*Strix occidentalis lucida*)		X				
Neotropical cormorant (*Phalacrocorax brasilianus*)					X	
Northern aplomado falcon (*Falco femoralis septentrionalis*)	X			X		
Northern goshawk (*Accipiter gentilis*)			X			
Southwestern willow flycatcher (*Empidonax traillii extimus*)	X				X	
Varied bunting (*Passerina versicolor*)					X	
Western burrowing owl (*Athene cunicularia hypugea*)			X			
White-faced ibis (*Plegadis chihi*)			X			
Reptiles						
Arid land ribbon snake (*Thamnophis proximus*)					X	
Blotched water snake (*Nerodia erythrogaster*)					X	
Dunes sagebrush lizard (*Sceloporus arenicolus*)			X		X	
Mottled rock rattlesnake (*Crotalus lepidus lepidus*)					X	
Texas horned lizard (*Phrynosoma cornutum*)			X			
Western river cooter (*Pseudemys gorzugi*)					X	

[a] Includes federal-endangered, -threatened, and -candidate species, state-endangered and -threatened species, and state-rare and -sensitive species. None of these species have been found during surveys at the WIPP sites. Due to revisions in the lists of endangered and threatened species, only two of the identified Federal candidate species (the swift fox and Pecos pupfish) are still listed.
[b] FE = federal-endangered species (USFWS 1995)
[c] FT = federal-threatened species (USFWS 1995)
[d] FC = federal-candidate species (USFWS 1995)
[e] SE = state-endangered species (NMDG&F 1995, Sivinski and Lightfoot 1995)
[f] ST = state-threatened species (NMDG&F 1995)
[g] SR = state-rare and -sensitive species (Sivinski and Lightfoot 1995)

Table 4-1
Species of Special Concern in Eddy County, New Mexico—Continued[a]

Name	FE[b]	FT[c]	FC[d]	SE[e]	ST[f]	SR[g]
Fish						
Bigscale logperch (*Percina macrolepida*)					X	
Blue sucker (*Cycleptus elongatus*)			X	X		
Gray redhorse (*Moxostoma congestum*)					X	
Greenthroat darter (*Etheostoma lepidum*)					X	
Headwater catfish (*Ictalurus lupus*)			X			
Mexican tetra (*Astyanax mexicanus*)					X	
Pecos bluntnose shiner (*Notropis simus pecosensis*)		X			X	
Pecos gambusia (*Gambusia nobilis*)	X				X	
Pecos pupfish (*Cyprinodon pecosensis*)			X		X	
Plains minnow (*Hybognathus placitus*)			X			
Rio Grande shiner (*Notropis jemezanus*)			X			
Invertebrates						
Ovate vertigo (*Vertigo ovata*)			X		X	
Pecos springsnail (*Fontelicella pecosensis*)			X		X	
Texas hornshell (*Popenaias popei*)			X	X		
Plants						
Catchfly gentian (*Eustoma exaltatum*)						X
Chapline's columbine (*Aquilegia chrysantha chaplinei*)						X
Desert parsley (*Pseudocymopterus longiradiatus*)						X
Dune unicorn plant (*Proboscidea sabulosa*)						X
Few-flowered jewelflower (*Streptanthus sparsifloras*)			X			X
Gray sibara (*Sibara grisea*)						X
Guadalupe cliff daisy (*Chaetopappa hersheyi*)			X			X
Guadalupe mescal bean (*Sophora gypsophila guadalupensis*)						X
Guadalupe milkwort (*Polygala rimulicola rimulicola*)						X
Guadalupe penstemon (*Penstemon cardinalis regalis*)						X
Guadalupe rabbitbrush (*Chrysothamnus nauseosus texemsis*)			X			X
Guadalupe smooth aster (*Aster laevis guadalupensis*)			X			
Gypsum milkvetch (*Astragalus gypsodes*)						X
Gypsum wild buckwheat (*Erigonum gypsophilum*)		X		X		
Hitchcock's mockorange (*Philadelphus hitchcockianus*)						X
Kuenzler's hedgehog cactus (*Echinocereus fendleri kuenzleri*)				X		
Lee's pincushion cactus (*Coryphantha sneedii leei*)		X		X		
Lloyd's hedgehog cactus (*Echinocereus lloydii*)	X			X		
McKittrick pennyroyal (*Hedeoma apiculata*)						X
Scheer's pincushion cactus (*Coryphantha scheeri scheeri*)				X		
Shining coral root (*Hexalectris nitida*)			X	X		
Texas tobacco root (*Valeriana texana*)						X
Tharp's bluestar (*Amsonia tharpii*)			X	X		
Waterfall milkvetch (*Astragalus waterfallii*)						X
Wright's water-willow (*Justicia wrightii*)			X			X

[a] Includes federal-endangered, -threatened, and -candidate species, state-endangered and -threatened species, and state-rare and -sensitive species. None of these species have been found during surveys at the WIPP sites. Due to revisions in the lists of endangered and threatened species, only two of the identified Federal candidate species (the swift fox and Pecos pupfish) are still listed.
[b] FE = federal-endangered species (USFWS 1995)
[c] FT = federal-threatened species (USFWS 1995)
[d] FC = federal-candidate species (USFWS 1995)
[e] SE = state-endangered species (NMDG&F 1995, Sivinski and Lightfoot 1995)
[f] ST = state-threatened species (NMDG&F 1995)
[g] SR = state-rare and -sensitive species (Sivinski and Lightfoot 1995)

The first investigation excavated three sites identified in FEIS that were in areas which could have been disturbed during construction activities. Two of the sites were plant-collecting and processing sites, and one was a base camp used between 1,000 B.C. and 1,400 A.D. The second investigation covered Control Zones III and IV and areas identified for possible land exchange. Sites encountered in the second investigation tended to lack evident or intact features. No definitive structures were identified. Of the 40 new sites identified, 14 were considered eligible for inclusion in the National Register of Historic Places (NRHP). The eligible and potentially eligible sites were mapped and DOE activities have avoided disturbance of these sites. As a result of this past work, about 37 percent of the WIPP withdrawal area (1,551 hectares [3,830 acres]) have been intensively inventoried for cultural resources.

To date, 60 archeological sites have been recorded in the withdrawal area, including 91 isolated occurrences (single or few artifacts, or isolated features). Sites and isolates are almost exclusively prehistoric in origin, and only one site with both prehistoric and historic components has been recorded. Based on the inventory data, and assuming environmental homogeneity and a fairly even distribution of archeological sites, DOE estimates that the WIPP site may contain about 99 archeological sites and 153 isolates (1993a).

There are no known Native American sacred sites or burials in the Land Withdrawal Area. Prior to the passage of the LWA in 1992, BLM managed the cultural resources on WIPP. In 1994, a memorandum of understanding between DOE and the Department of the Interior transferred management responsibility for cultural resources to DOE. Cultural resources are currently managed according to guidelines set forth in the WIPP Land Management Plan (DOE 1993a).

4.1.6 Socioeconomic Environment

The socioeconomic ROI for WIPP, as defined in FEIS (DOE 1980) and SEIS-I (DOE 1990), is Eddy and Lea counties in southeast New Mexico.[1] Any major changes in future activities undertaken at the WIPP site would have their most immediate socioeconomic effects in the two-county ROI. As of 1990, over 90 percent of WIPP employees resided in Eddy and Lea counties.

Previous analyses of the socioeconomic impacts of WIPP on southeastern New Mexico occurred in Fiscal Year (FY) 1982 (Adcock et al. 1983), FY 1987 (Lansford et al. 1988), and most recently FY 1988 (Adcock et al. 1989). Socioeconomic analyses were also conducted for SEIS-I (DOE 1990). Employment and wage characteristics for 1994 are based on information provided by the New Mexico Department of Labor (NMDOL 1994) and the Bureau of Business and Economic Research of the University of New Mexico (BBER 1995). Other social and demographic characteristics reported

CHANGES IN SOCIOECONOMICS

Since publication in 1990 of SEIS-I, the following changes have occurred:

- *Census Information* - Demographic characteristics in SEIS-II are based on 1990 U.S. Bureau of the Census information as well as more recent data.
- *Economic Characteristics* - SEIS-II uses economic characteristics involving employment and wages covered by unemployment insurance from 1980 through 1990, based on 1994 information provided by the New Mexico Department of Labor and the University of New Mexico Bureau of Business and Economic Research.

[1] Towns included in this ROI include Artesia, Atoka, Black River village, Carlsbad, El Paso Gap, Hope, Lakewood, Loco Hills, Loving, Malaga, Riverside, Seven Rivers, and Whites City in Eddy County. It also includes Caprock, Crossroads, Eunice, Hillburn City, Hobbs, Humble City, Jal, Lovington, Maljamar, McDonald, Monument, Nadine, Oil Center, and Tatum in Lea County.

for 1990 are based on 1990 Census information and more recent data compiled by the U.S. Bureau of the Census (1994).

4.1.6.1 Background Characteristics

The construction of WIPP had some notable socioeconomic impacts in the ROI from 1981 through 1986. Subsequently, WIPP has had a relatively smaller impact on the socioeconomic characteristics in the ROI relative to changes from the extraction of oil and natural gas, the major industry of Eddy and Lea counties. This industry experienced a loss of almost one-third of its 1980 work force over the decade, substantially dampening the population growth in the ROI (BBER 1995). Correspondingly, WIPP-related activities tended to have a stabilizing effect on the local economy, particularly in Eddy County.

Table 4-2 shows that in 1990, four years after the major WIPP construction effort, the total population in the ROI was 104,370. This population is comprised of approximately 81.9 percent White, 32.4 percent Hispanic (both White and non-White), and 0.5 percent Native American. The ROI has smaller portions of Hispanic and Native American populations when compared to New Mexico as a whole, where the two groups comprise 38.2 percent and 8.9 percent, respectively. About 56 percent of the total ROI population is between the ages of 18 and 65. Overall, 65.4 percent of the ROI population has completed high school, with 11.2 percent attaining a baccalaureate degree or higher.

Table 4-2
1990 Population and Community Characteristics by County in ROI[a]

Characteristic	Eddy	Lea	ROI Total[b]
Total population	48,605	55,765	104,370
Population by Race and Ethnicity			
White (percent)	81.5	82.2	81.9
Black (percent)	1.7	4.7	3.3
Native American (percent)	0.5	0.6	0.5
Asian (percent)	0.4	0.4	0.4
Other or Non-Reporting (percent)	15.9	12.1	13.9
Hispanic[c] (percent)	35.3	29.8	32.4
Population by Age and Education			
Percentage under 18	30.2	33.2	31.8
Percentage 65 and over	15.2	10.6	12.7
Percentage high school	67.3	63.8	65.4
Percentage bachelor degree	10.9	11.5	11.2
Total School Enrollment	13,489	16,457	29,946
College	2,010	2,765	4,475
Elementary or high schools	10,790	12,859	23,649
Community hospitals	2	2	4
Number of beds	156	278	434
Number of physicians	54	40	94

[a] ROI as defined for the socioeconomic environment constitutes a two-county aggregation based on 1990 census information.
[b] ROI percent totals are calculated on the total class level divided by the total ROI population.
[c] Hispanic is an ethnic characterization and consequently persons of Hispanic origin can be of any race.

Source: U.S. Bureau of the Census 1994.

The ROI experienced slight advances in personal income in spite of the general downturn in oil and natural gas extraction during the 1980s. The median household and per capita income levels shown in Table 4-3 for the ROI were $23,305 and $10,241, respectively. Table 4-3 also shows that 17.4 percent of all families in the ROI were below the national poverty threshold. Poverty thresholds vary by family size and number of related children under 18 years of age. For example, the U.S. Bureau of the Census (1994) defined the national poverty threshold for a family of five persons in 1989 to be $14,900. New additions to the housing stock during 1990 through 1992 were relatively small across the ROI, while vacancy rates for rental units suggested ample availability of rental housing for under $350 per month.

Table 4-3
Income, Poverty, and Housing Characteristics (1989-1992) by County in ROI

Characteristic	Eddy	Lea	ROI Total
Median household income (dollars)	23,418	23,352	23,305
Per capita income (dollars)	10,490	10,025	10,241
Families below poverty line	2,162	2,806	4,968
Percentage of families below poverty line	16.2	18.5	17.4
Persons below poverty line	9,755	12,309	22,064
Percentage of persons below poverty line	20.4	22.4	21.1
Total housing units	20,134	23,333	43,467
Median value of owner-occupied units (dollars)	44,800	39,600	42,200
Median gross rent (dollars)	304	312	308
Vacancy rate	13.2	17.3	15.41
New building permits (1990-1992) as percentage of 1990 housing stock	<1	<1	<1

Source: U.S. Bureau of the Census 1994.

4.1.6.2 Role of WIPP in the Economic Base

Table 4-4 lists recent information on local employment and wage earnings for the ROI. During 1994, a total of 38,094 employees earned $858 million in covered wages (wages covered by unemployment insurance) (NMDOL 1994). The most influential economic sectors in the ROI involved the extractive industries, the trade and service sectors, and government activities.

Given the stability of WIPP funding over the 1990s, the economic base of the ROI has been relatively less sensitive to changes in WIPP activities than to other large-scale enterprises such as the oil and gas industry. Declines in that industry in the 1980s resulted in lower employment and wage earnings, while upturns in the 1990s have resulted in higher employment and wage earnings. Future growth and diversification of the economic base in the ROI would tend to diminish the economic impact of future changes in WIPP activities.

The direct economic impact of the anticipated WIPP operations reflects the levels of wage and salary payments to WIPP employees and the size of business and government procurement associated with WIPP construction and operations activities. At the time of the FY 1988 study, $24.3 million was paid in direct WIPP wages and salaries to 661 site personnel, while nonsalary expenditures were estimated to be $95.3 million (Adcock et al. 1989). In contrast, WIPP-related employment and covered wages in 1994 accounted for 1,005 jobs and annual wages of

Table 4-4
ROI County Employment and Covered Wages (in Millions of 1994 Dollars)

Sector	Eddy		Lea		ROI Total	
	Employees	Wage	Employees	Wage	Employees	Wage
Agriculture	513	6.9	232	3.0	745	9.9
Mining	2,985	103.1	4,297	132.4	7,282	235.5
Construction	1,006	19.0	1,188	24.6	2,194	43.6
Manufacturing	921	31.0	529	9.8	1,450	40.8
Transportation and Utilities	1,628	52.2	1,487	51.7	3,115	103.9
Trade	3,798	51.4	4,891	77.9	8,689	129.3
F.I.R.E.[a]	614	13.7	529	12.1	1,143	25.8
Services[b]	3,753	62.9	3,668	65.9	7,421	128.8
Government						
Federal	425	15.7	123	4.2	548	19.9
State	420	8.9	238	5.6	658	14.5
Local	2,162	49.2	2,687	56.8	4,849	106
Totals	18,225	414	19,869	444	38,094	858
Unemployed percent	6.8		5.5		6.1	

[a] Finance, Insurance, and Real Estate
[b] The New Mexico Department of Labor classifies WIPP employees under the service sector industry, SIC 87.

Source: NMDOL 1994 and U.S. Bureau of the Census 1994.

approximately $44.56 million. Accordingly, WIPP-related jobs accounted for 2.6 percent of total 1994 employment in Eddy and Lea counties and approximately 5.2 percent of covered wage earnings.

Nonsalary expenditures are mainly for regional support services, materials, capital equipment, and construction. However, WIPP outlays are also used to pay for business and government expenditures, including grants, community assistance, and out of region expenditures made through or by the local WIPP project office (DOE 1990).

The indirect economic impact of the anticipated WIPP operations is reflected by the subsequent spending and creation of new jobs that follow initial WIPP outlays in any given year. To assess the economic impacts of changes in the funding at the WIPP site, Adcock et al. (1989) estimated an economic activity multiplier value of 2.19 for FY 1988. That is, for every $1.00 spent by WIPP on materials, labor, benefits, equipment and services, another $1.19 worth of goods and services was generated in the ROI for a total impact of $2.19.

Relative to the $24.3 million of direct salaries and wages paid in FY 1988, an estimated additional $26.2 million of indirect wages and salaries were paid in the ROI in FY 1988 in support of 1,153 indirect jobs (Lansford et al. 1988). Meanwhile, the direct nonsalary expenditures of $95.3 million were estimated to generate an additional $113.6 million of indirect nonsalary expenditures in the local economy.

4.1.6.3 Environmental Justice

Environmental justice in the context of this document refers specifically to the potential for minority and low-income populations to bear a disproportionate share of high and adverse environmental impacts from activities at WIPP under the various SEIS-II alternatives. The environmental justice ROI covers all populations within an 80-kilometer (50-mile) radius of the reservation boundary of WIPP.[1] This region includes parts of three counties in New Mexico (Chaves, Eddy, and Lea) and parts of seven counties in Texas (Andrews, Culberson, Gaines, Loving, Reeves, Ward, and Winkler). Seventy-five percent of the ROI lies within New Mexico, and the remaining 25 percent lies within Texas.

The following population data are derived from the 1990 Census of Population and Housing (U.S. Bureau of the Census 1994). Within the Environmental Justice ROI, the total population of 101,129 persons includes 4.1 percent non-White, 32.6 percent Hispanic, and 36.8 percent minority (all except White non-Hispanic persons). In addition, 21.5 percent of the total population had 1989 incomes below the poverty level, as defined by the U.S. Bureau of the Census. There are no Native American reservations in the ROI. Figures 4-7 and 4-8 display maps of the distribution of minority and low-income populations according to the percentage of the block group population in the environmental justice ROI. Block grouping is a division of territory, the size of which varies according to population density, that has approximately 400 households.

The proportion of Hispanic, minority, and low-income persons in the ROI are all greater than in the United States as a whole. Also, the proportion of low-income persons in the ROI is greater than in both New Mexico and Texas. Finally, the proportion of Hispanic persons in the ROI is smaller than in New Mexico but greater than in Texas.

4.1.7 Transportation

SEIS-I briefly describes the transportation routes leading to WIPP. The site can be reached by rail or highway. DOE has constructed a rail spur to the site from the Burlington Northern and Santa Fe Railroad 10 kilometers (6 miles) west of the site. The site can also be reached from the north and south access roads constructed for the WIPP project. The north access road intersects U.S. Highway 62/180 (U.S. 62/180) 21 kilometers (13 miles) north of WIPP. The south access road intersects New Mexico Highway 128 6.5 kilometers (4 miles) to the southwest of WIPP. Transportation routes from principal DOE sites and facilities are shown in Appendix E, which also presents additional information on transportation methods and routes.

4.1.8 Background Radiation

The background radiation conditions in the vicinity of WIPP are influenced by natural sources of radiation, fallout from nuclear tests, and Project Gnome, a local research project (DOE 1990).

DOE established long-term radiological monitoring programs in southeastern New Mexico prior to the WIPP project, to determine the widespread impacts of nuclear tests at the Nevada Test Site

[1] Towns included in this ROI include Artesia, Atoka, Black River village, Carlsbad, El Paso Gap, Hope, Lakewood, Loco Hills, Loving, Malaga, Riverside, Seven Rivers, and Whites City in Eddy County, New Mexico. It also includes Eunice, Hobbs, Humble City, Jal, Lovington, Maljamar, Monument, Nadine, and Oil Center in Lea County. It includes Mentone in Loving County, Texas, and both Arno and Orla in Reeves County, Texas. The other counties in New Mexico and Texas that are part of this ROI have no communities within the 80-mile radius.

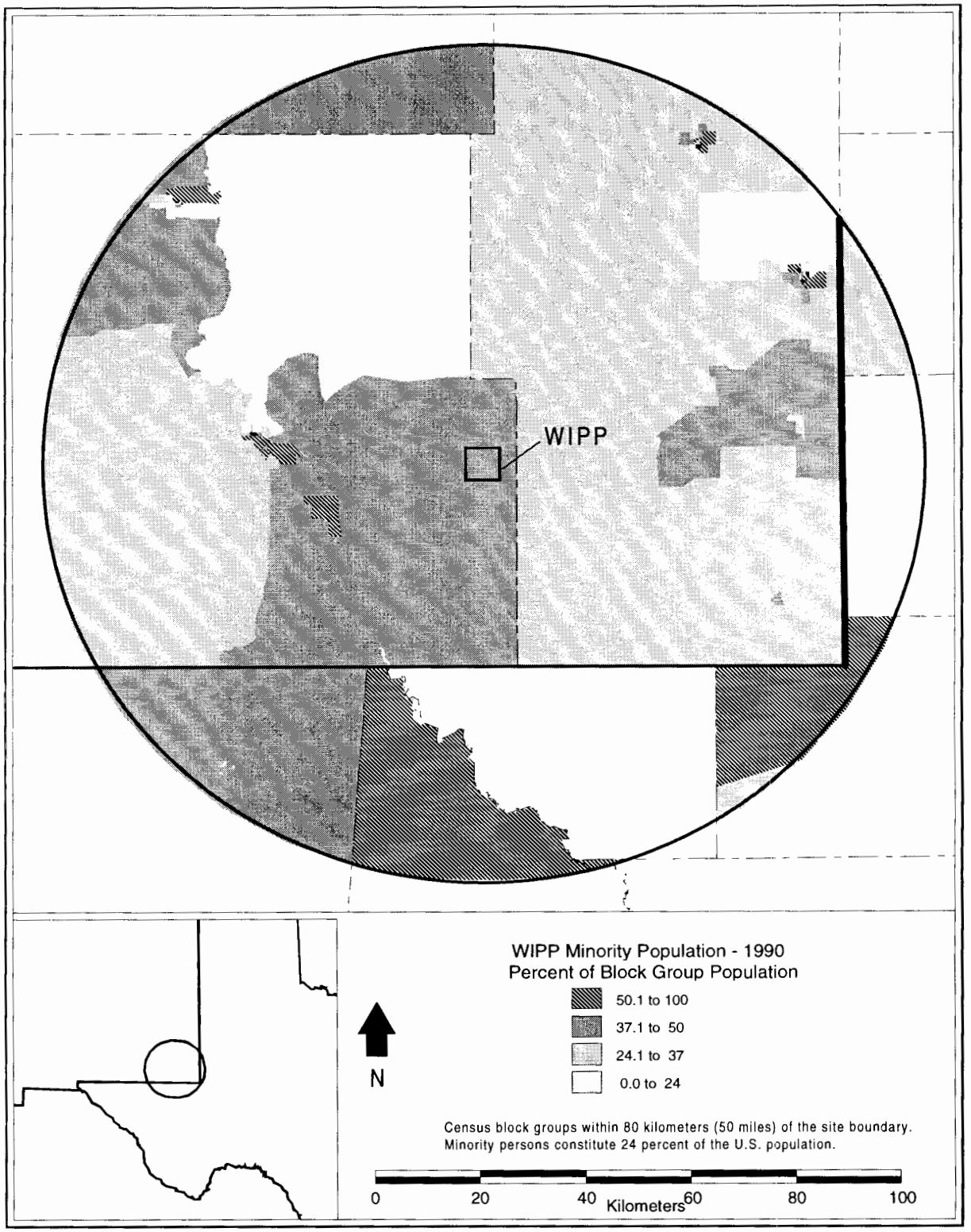


Figure 4-7
Minority Population

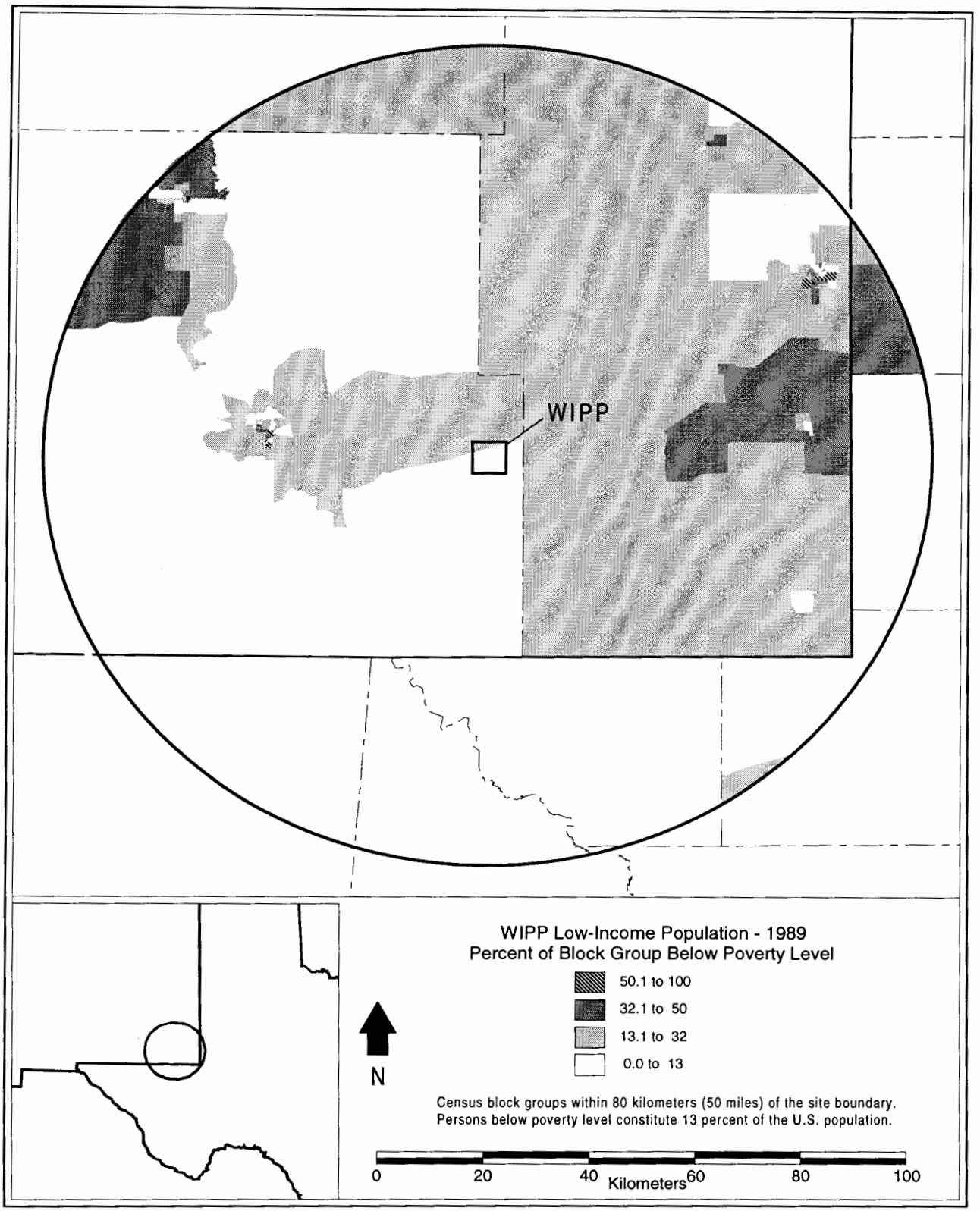


Figure 4-8
Low-Income Population

(NTS) and to evaluate the effects of Project Gnome. The background radiation levels measured at WIPP from 1976 to 1979 are discussed in FEIS (DOE 1980).

> ***RADIOLOGICAL ENVIRONMENT***
>
> *Background Radiation* - Since publication of SEIS-I, the WIPP Radiological Baseline Program (RBP) has shown that there has been little variation in mean gross alpha, beta, and gamma levels in airborne particulates. Radionuclide concentrations in soil, surface water, sediment samples, and key organisms have fallen within the expected ranges and have not indicated any excessively high environmental concentrations.

The WIPP RBP was initiated in 1985 to describe background levels of radiation and radionuclides in the WIPP environment prior to the underground emplacement of radioactive waste (DOE 1990). The RBP consists of five subprograms: (1) atmospheric baseline, (2) ambient radiation (gamma radiation), (3) terrestrial baseline (soils), (4) hydrologic baseline (surface water, bottom sediments, and groundwater), and (5) biotic baseline (radiological parameters in key organisms along potential radionuclide-migration pathways). Mean gross alpha activity in airborne particulates has shown little variation and is within the range of 1 to 3 x 10^{-15} microcuries per milliliter. Mean gross beta activity in airborne particulates fluctuates but is typically within the range of 1 to 4 x 10^{-15} and 1 to 4 x 10^{-14} microcuries per milliliter. The average level of gamma radiation in the environment is approximately 66 millirem per year. On average, a person in the United States receives an effective dose equivalent of about 350-360 millirem per year from all sources of radiation (DOE 1995h, 1995k). Radionuclide concentrations in soil, surface water, sediment samples, and key organisms fall within expected ranges and do not indicate any unexpected environmental concentrations (DOE 1990).

In 1994, atmospheric particulates, ambient radiation, soil, surface water and sediment, groundwater, and biota (vegetation, fish, rabbit, and deer) samples were collected throughout the year from a number of locations and analyzed radiologically. Table 4-5 highlights the radionuclides sampled in the WIPP vicinity. An estimated annual dose of approximately 65 millirem was determined, indicating no unusual levels of environmental radioactivity exist at WIPP (DOE 1995f).

Table 4-5
Radionuclides Sampled in the Vicinity of WIPP

Name	Symbol	Particulate	Soil	Surface-water/ Sediment	Groundwater	Biota
Actinium-228	^{228}Ac			X		X
Beryllium-7	^{7}Be	X				
Potassium-40	^{40}K	X	X	X	X	X
Cobalt-60	^{60}Co	X	X	X	X	X
Strontium-90	^{90}Sr	X	X	X	X	X
Cesium-137	^{137}Cs	X	X	X	X	X
Radium-226/228	$^{226/228}Ra$	X	X	X	X	X
Thorium-228/230/232	$^{228/230/232}Th$	X	X	X	X	X
Uranium-233/234/235/238	$^{233/234/235/238}U$	X	X	X	X	X
Plutonium-238/239/240/241	$^{238/239/240/241}Pu$	X	X	X	X	X
Americium-241	^{241}Am	X	X	X	X	X
Lead-210	^{210}Pb	X	X	X	X	X
Polonium-210	^{210}Po	X	X	X	X	X

As discussed in FEIS (DOE 1980) and SEIS-I (DOE 1990), Project Gnome resulted in a nuclear device being detonated underground approximately 14 kilometers (9 miles) south-southwest of the WIPP site in 1961 as part of the Plowshare Program sponsored by the Atomic Energy Commission. In 1972, the EPA established a program to monitor radionuclide levels in surface water and groundwater in areas potentially affected by Project Gnome. EPA (1984) published the results in its "Off-Site Environmental Monitoring Reports for Nuclear Test Areas Around the United States." In June 1995, the Environmental Evaluation Group (EEG) conducted a limited radiological survey of the Project Gnome area (EEG 1995) as well as a radiochemical analyses with a commercial laboratory. The results indicated that there were elevated levels of plutonium-238 (Pu-238), plutonium-239 (Pu-239), plutonium-240 (Pu-240), and americium-241 (Am-241) in localized surface soils at the Gnome site. Although the results indicated measurable TRU contamination at the Gnome site, EEG reported that the levels did not appear to present any immediate health and safety concern.

4.2 EXISTING ENVIRONMENT AT THE TEN MAJOR GENERATOR-STORAGE SITES

The following sections briefly summarize the existing environments at the 10 major generator-storage sites listed in Chapter 1. Maps showing the locations of the sites can be found in Chapter 3.

4.2.1 Argonne National Laboratory-East (ANL-E)

ANL-E occupies 690 hectares (1,700 acres) in northeast Illinois, in DuPage County, approximately 35 kilometers (22 miles) southwest of downtown Chicago, Illinois. The site is north of the Des Plaines River valley, south of Interstate-55, and west of Illinois Highway 83. Comprised of several buildings, ANL-E is a multi-program laboratory that conducts basic and applied research in the areas of reactor development, physical sciences, and life and environmental sciences. Technology commercialization and science education are also ANL-E missions (META/Berger 1995).

Regional land use surrounding ANL-E is characterized by high concentrations of urban development, including commercial, industrial, public, and residential usage. Several large forest preserves are east and southeast of the site. The site itself is in a suburban area. ANL-E uses only 80 hectares (200 acres) of the site for DOE activities, devoting the rest to forest and landscape areas (META/Berger 1995).

Four on-site wells provide the water supply for ANL-E. An average of 3,000 to 3,400 cubic meters (800,000 to 900,000 gallons) of water is pumped from the wells each day. ANL-E is now in the process of converting from local groundwater supplies to a municipal supply obtained from Lake Michigan (Holdren et al. 1995). The current site load for electricity is 23 megawatts (META/Berger 1995).

The ANL-E is located in a Class II designated PSD air quality area. The nearest Class I designated PSD area is the Seney National Wildlife Refuge located approximately 525 kilometers (325 miles) north of the site in Seney, Michigan. The EPA classifies the site and the surrounding counties as severe nonattainment areas for the criteria pollutant ozone. All other surrounding counties and areas are in attainment of the remaining NAAQS criteria pollutants except for Lyons Township in southeast Chicago, which is listed as a moderate nonattainment area for PM_{10} (META/Berger 1995).

There are no known active tectonic features within 100 kilometers (62 miles) of the site. Several areas of considerable seismic activity are present at moderate distances from ANL-E, including the New Madrid fault zone in southeastern Missouri (a fault zone along the southern Illinois-Indiana border) and one in western Ohio. Horizontal accelerations greater than 0.1 gravity are estimated to occur on the site approximately once in 600 years (META/Berger 1995).

ANL-E is on the northern margin of the Des Plaines River valley. The largest on-site stream is Sawmill Creek, which originates north of the site and enters the Des Plaines River about 2 kilometers (1.25 miles) southeast from the center of the site. ANL-E is located approximately 46 meters (150 feet) above the Des Plaines River and thus is not subject to major flooding (META/Berger 1995). Sawmill Creek is currently the receiving body for effluent from ANL-E treatment facilities. The quality of waters in both Sawmill Creek and the Des Plaines River is poor. The Des Plaines River is used for neither agricultural nor domestic supplies for more than 100 kilometers (62 miles) downstream of ANL-E (Holdren et al. 1995).

ANL-E uses two principal aquifers for its water supply. The upper aquifer is about 60 meters (200 feet) thick and supplies potable water. The other aquifer is below the first, lying between 150 and 460 meters (500 and 1,500 feet) beneath the surface. The two aquifers are not directly connected and pumpage from the upper aquifer does not appear to affect the lower aquifer. No aquifers in the ROI are considered sole source aquifers under Safe Drinking Water Act regulations (META/Berger 1995).

Federal-listed threatened or endangered species are not known to reside on the ANL-E site. The site is known to contain one state-listed endangered bird. Six federally- or state-threatened or endangered species reside in the area and may possibly reside on the site (META/Berger 1995).

As of 1994, a complete survey of ANL-E revealed 43 prehistoric and 6 historic archeological properties, but no sites listed with the NRHP or designated as National Historic Landmarks. Three sites are potentially eligible for the NRHP, 20 sites are not considered eligible, and 26 sites have not been evaluated. The potential of ANL-E to contain traditional cultural resources of interest to Native American groups has also not been evaluated (META/Berger 1995).

The counties of DuPage, Cook, Kane, and Will, in Illinois comprise the economic ROI in which 95.4 percent of all ANL-E's employees reside. About 4,500 persons were employed at ANL-E. The ROI total population in 1992 was 6,568,800, of which approximately 98 percent was urban. Within the ROI, Whites comprise approximately 68.5 percent of the population, Blacks comprise 21.2 percent, and Hispanics comprise 12.1 percent. In 1989, about 9 percent of all families were below the poverty level. The dominant industries in the ROI include manufacturing, finance, insurance, real estate, and government (META/Berger 1995).

The ANL-E ROI is served by Interstate Highways 55, 80, 294, and 355. In addition, U.S. Routes 34 and 45/20 and Illinois Route 83 provide local access. The Chicago metropolitan area has a number of rail lines which can be accessed by truck from ANL-E. The nearest major airport is Chicago's O'Hare International Airport (META/Berger 1995).

Radionuclide sampling at ANL-E is carried out for soil, water, and air. The 1990 data indicated no substantial difference between on-site and off-site radionuclide concentrations in soil samples. In 1993, measurable levels of several radionuclides were detected in Sawmill Creek downstream from the wastewater treatment plant outfall. The concentrations of all these radionuclides were only a small fraction of the DOE-derived concentration guides for water. In 1993, elevated levels

of Am-241, cesium-137 (Cs-137), cobalt-60 (Co-60), and Pu-239 were found in sediments below the outfall and are attributed to past releases. Radionuclides found in groundwater include Cs-137, strontium-90 (Sr-90), and tritium (H-3). In 1993, all radionuclide monitoring results were less than the limits established by the Safe Drinking Water Act. Airborne particulates and other airborne sources added to the background radiation in the ANL-E area.

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 3×10^{-3} latent cancer fatalities (LCFs). The population within this area was 7,900,000. The annual dose from airborne radionuclides to the maximally exposed individual (MEI) during 1994 would result in a 8×10^{-7} percent chance of an LCF. The corresponding dose is below the National Emission Standard for Hazardous Air Pollutants (NESHAP) limit.

4.2.2 Hanford Site (Hanford)

Hanford covers about 1,450 square kilometers (560 square miles) of the southeastern part of the state of Washington in parts of Benton, Grant, and Franklin Counties. The nearest city, Richland, Washington, borders the site on its southeast corner. The site is bounded on the east by the Columbia River, on the west by the Rattlesnake Hills, and on the north by Saddle Mountain. The site has a number of facilities including retired plutonium production reactors, operating reactors, waste management and spent nuclear fuel processing facilities, and nuclear research and development laboratories (DOE 1995b).

Land on the Hanford site is used primarily by DOE. However, there are also areas used as a wildlife refuge and for game management. The land adjacent to the site is either urban, commercial, or agricultural. Agricultural areas include irrigated and dry-land farming and grazing. The Columbia River adjacent to the site is heavily used for recreation (DOE 1995b).

The Columbia River is the principal source of water for Hanford. In 1992, the site consumed approximately 15 million cubic meters (4 billion gallons) of water. The Bonneville Power Administration provides electricity. In 1992, electricity consumption at the site was approximately 340,000 megawatt-hours, with a power demand of 57 megawatts (DOE 1995b).

Air quality in the Hanford region is well within the State of Washington and EPA standards for criteria pollutants, except that short-term particulate concentrations occasionally exceed the PM_{10} standard (DOE 1995b). Hanford is in a Class II air quality area (META/Berger 1995). The Class I areas nearest to the site are Goat Rocks Wilderness Area and Mount Rainier National Park, both about 145 kilometers (90 miles) away. Two other Class I areas are within 175 kilometers (110 miles) of the site (DOE 1995b).

The climate of the area is semiarid, with hot, dry summers and cool winters. Temperatures range from an average high of 2 degrees Celsius (36 degrees Fahrenheit) in January to an average high of 35 degrees Celsius (95 degrees Fahrenheit) in July (DOE 1995b). On average, thunderstorms occur 11 days per year, mostly in summer. The annual average precipitation is 16 centimeters (6.3 inches). The prevailing wind is from the west and the monthly average wind speeds range from 3 meters per second (7 miles per hour) in the winter to 4 meters per second (9 miles per hour) in the summer (META/Berger 1995). Tornadoes are extremely rare, occurring within 160 kilometers (100 miles) of the site about once every three years. The estimated probability of a tornado striking a point on the site is 9.6×10^{-6} per year.

Hanford is on a low-lying, modified plain of the Columbia River. Recent alluvial or windblown sands comprise the surface of the plain, with basaltic lava flows and various layers of gravel, silts, and clays underneath (DOE 1995b).

Earthquake activity in the area of Hanford has historically been low-to-moderate. The site is in a Uniform Building Code Seismic Risk Zone 2B. The largest shock recorded near the site was approximately 4.5 to 5.0 on the Richter scale (Modified Mercalli Intensity of V) in Corfu, 35 kilometers (22 miles) north of the site, in 1918. Another Modified Mercalli Intensity V quake occurred in the area in 1973. The site often experiences low intensity earthquakes occurring in clusters over a short period of time. Volcanic hazards are low as the site is located approximately 160 kilometers (100 miles) east of the Cascade Range, which includes several volcanic vents. Foreseeable volcanic effects at the site are limited to windborne volcanic ash (DOE 1995b).

The Columbia River passes through the northern part of Hanford and forms part of the eastern boundary. The Yakima River is located near the southern portion of the site. There are also two intermittent creeks. Upstream dams control potential flooding from the Columbia River. Minor flooding away from on-site facilities occurs from the other watercourses. The water quality of the Columbia River is high, and the river contributes to the water supply for the site and for nearby cities. Radiological monitoring shows low levels of radionuclides in the river, considerably below concentration guidelines established by EPA drinking water standards. Wastewaters are discharged to several ponds on the site and the Columbia River. Nonradiological contaminant concentrations are within Washington State Water Quality Standards (DOE 1995b).

There are unconfined aquifers located beneath Hanford (DOE 1995b). No aquifers are considered sole-source aquifers (META/Berger 1995). In 1993, several radionuclides and nonradioactive chemicals were detected at levels exceeding EPA drinking water standards and/or DOE derived concentration guides (DOE 1995b). Preliminary investigations have identified four major groundwater contaminant plumes that have been found to enter the Columbia River in at least three locations (META/Berger 1995). Groundwater beneath the site is not used for human consumption or food production, except for one well used for drinking at one of the facilities. Above-background levels of radionuclides have been detected in this well; however, the levels are considerably below EPA drinking water standards (DOE 1995b).

Hanford, a shrub-steppe environment dominated by cheatgrass and sagebrush, includes 10 different types of plant communities. Deer and elk are the major large animals, and coyotes are the main large predators (DOE 1995b). Wetlands existing along the Columbia River and other streams and seeps support extensive stands of various types of vegetation as well as the waterfowl that use them for nesting. The river supports 44 species of fish, including salmon and trout, which use it as a spawning area (META/Berger 1995). A 310-square-kilometer (120-square-mile) area of the site set aside for ecological studies, a wildlife refuge, and a game management area comprises the Arid Land Ecology Reserve.

The entire Hanford site has been designated a National Environmental Research Park (NERP) (DOE 1995b). There are six federal- or state-threatened or endangered species of birds on the Hanford site. One state-endangered mammal and four state-threatened or endangered plant species are also found. In addition, there are 12 other species of animals which are federal- or state-classified as species of concern (META/Berger 1995).

As of 1992, 248 prehistoric archeological sites were recorded, 48 of which are on the NRHP (DOE 1995b). In addition, 11 historic archeological sites and 11 other properties are also listed on

the NRHP (META/Berger 1995). Archeological sites include the remains of villages, campsites, cemeteries, monuments, hunting sites, and quarries. Several Native American groups retain traditional secular and religious ties to the region. Some native plant and animal foods used in religious ceremonies can be found on the Hanford site (DOE 1995b).

The primary socioeconomic impact area includes the tri-cities (Richland, Kennewick, and Pasco) and the counties of Franklin and Benton in Washington state. The estimated population for this area in 1992 was about 160,000. The larger economic ROI includes eight other counties in both Washington and Oregon. The estimated population for this ROI in 1992 was about 550,000. The primary economies of the economic ROI, each employing about 40,000 to 50,000 people, include agriculture/fishing/lumbering, manufacturing, trade, services, and government (DOE 1995b). The environmental justice ROI, which is the area within an 80-kilometer (50-mile) radius from the site, contains about 380,000 people. This ROI population includes 20 percent minority, 18 percent low-income (DOE 1995b), and 19 percent Hispanic (META/Berger 1995). The site employs about 14,200 people, accounting for almost 25 percent of the nonagricultural employment in Benton and Franklin Counties. These two counties also account for approximately 93 percent of site employees (META/Berger 1995).

DOE has entered into agreements with the tribal governments representing the Yakama Indian Nation, Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. These agreements pertain to the core environmental programs and the emergency preparedness and response program.

U.S. Highways 12 and 395, Interstate-82, and State Route 240 run through the Hanford site. Two railroads also connect the area with much of the rest of the nation.

High-level radioactive waste has been accumulating at Hanford since 1944. Before 1970, TRU waste was disposed of on-site in unlined trenches; since 1970, however, Hanford has stored TRU waste in aboveground storage facilities. Besides high-level radioactive waste, the site also has low-level waste, mixed waste, and hazardous waste stored in large amounts. Hanford is included on the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) National Priorities List.

In 1993, radiation workers at the site were monitored and found to have average annual doses resulting in 8.0×10^{-6} LCFs per individual (DOE 1995b). The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 0.3 LCFs. The population within this area was 380,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 3×10^{-7} percent chance of an LCF. The corresponding dose is below the NESHAP limit. About 50 cancer deaths could be projected by the total public radiation dose from Hanford activities since 1944. Essentially all of these would have been the result of radiation exposures received during 1945 (DOE 1995b).

4.2.3 Idaho National Engineering Laboratory (INEL)

INEL encompasses 230,000 hectares (568,000 acres) within five counties in southeastern Idaho. The site is located 44 kilometers (27 miles) west of Idaho Falls, Idaho, on the Eastern Snake River Plain in the Basin and Range Province of North America. The site is bordered by mountain ranges and volcanic buttes (DOE 1995b).

Land at INEL is used for DOE operations, recreation, grazing, and environmental research. About 2 percent of the total INEL site area (4,600 hectares [11,400 acres]) is used for facilities and operations. Recreational uses include public tours of general facility areas and controlled hunting. Between 121,000 and 142,000 hectares (300,000 and 350,000 acres) are used for cattle and sheep grazing. BLM does not allow grazing within 3 kilometers (2 miles) of any nuclear facility, and, to avoid the possibility of milk contamination by long-lived radionuclides, does not permit dairy cattle anywhere on the site. BLM also manages some of the undeveloped areas for wildlife habitat. No mineral exploration or development is allowed on INEL land (DOE 1995b).

Site activities at INEL withdraw an average of 7.4 million cubic meters (1.9 billion gallons) of groundwater per year. The peak demand on the INEL electric system from 1990 to 1993 was about 40 megavolt-amperes, and the average usage was approximately 200,000 megawatt-hours per year (DOE 1995b).

The Craters of the Moon National Monument is 25 kilometers (15 miles) southwest of INEL's western boundary and is in a designated Wilderness Area for which Class I air quality standards must be maintained. Concentrations of criteria pollutants at the site are below the NAAQS, state, and PSD standards and limits. The estimated on-site concentrations of most toxic air pollutants are well below levels established for protection of workers. The maximum short-term benzene concentration slightly exceeds the standard at the highest predicted location. For off-site conditions, all toxic air pollutant levels are below reference levels (DOE 1995b).

INEL has an arid climate, with low relative humidity, wide daily temperature fluctuations, and large variations in annual precipitation. Thunderstorms occur 2-3 days per month during the summer; otherwise, severe weather is uncommon. No tornadoes were reported on-site from 1950 to 1988. The mean annual temperature is 5.6 degrees Celsius (42 degrees Fahrenheit) and the mean annual precipitation is 22 centimeters (8.7 inches) (DOE 1995b). Notable variations in wind direction and speed are characteristic of the INEL site. The prevailing wind direction ranges from west-southwest to north, and the average wind speed is about 3.2 meters per second (7.2 miles per hour) (Holdren et al. 1995).

The surface at the INEL site is comprised primarily of basaltic lava flows ranging in age from about 2,000 years to over 1 million years. The site also contains wind-blown loess and sand and floodplain sediments. Volcanic hazards at INEL can come from sources inside or outside the boundary of the site. Regional major volcanic activity has occurred at Craters of the Moon National Monument as recently as 2,100 years ago and at Yellowstone National Park (160 kilometers [100 miles] away) three times within the past 2 million years. The probability that volcanism would affect an INEL site facility is less than 2.5×10^{-5} per year (DOE 1995b).

There are volcanic rift zones lying across INEL, and the surrounding basin and range landscape also has frequent earthquakes (DOE 1995b). Two major earthquakes, of magnitude 7.3 and 7.5, have occurred within 100 miles of the site during the last 35 years (DOE 1996a). However, based on the seismic history and geologic conditions, earthquakes greater than magnitude 5.5 are unlikely within the site, though moderate to strong ground shaking from earthquakes within the nearby basin and range areas can affect the site (DOE 1995b).

The INEL site is covered with wind-blown sediments generally less than 2.1 meters (7 feet) deep (DOE 1995b). These soils have a low-to-moderate water erosion hazard and a moderate-to-high wind erodibility (DOE 1995k).

INEL is located in the Mud Lake-Lost River Basin, a closed drainage basin that includes three main tributaries (the Big and Little Lost Rivers and Birch Creek) which together drain approximately 753,000 hectares (1,860,000 acres). The Big Lost River crosses the site to an area of playas, or sinks, where water is discharged during an unusually wet year. However, surface water from this river, as well as the Little Lost River, does not usually reach the site. Water from Birch Creek flows into the site during the winter and infiltrates into channel gravels, where it recharges a local aquifer (DOE 1995b). During most years, all surface waters in the Little Lost River and Birch Creek are diverted to irrigation before entering the site (Holdren et al. 1995). Local flooding can occur at the site when the ground is frozen and runoff from melting snow is combined with heavy spring rains (DOE 1995b).

Chemical and radioactive parameters measured in the three rivers have not exceeded applicable drinking water quality standards. INEL site activities do not directly affect the quality of surface water outside the site because surface water does not flow directly off-site. Discharges from facilities are made to manmade seepages and evaporation basins, rather than natural surface water bodies (DOE 1995b).

INEL overlies the Snake River Plain Aquifer, the largest in Idaho, designated as a sole-source aquifer. This aquifer is the source of all water used at INEL. The depth to groundwater from the surface ranges from approximately 60 meters (200 feet) to over 270 meters (900 feet). Groundwater quality is affected by natural water chemistry and contaminants originating at INEL facilities. Concentrations of radionuclides in the aquifer have decreased over time, primarily due to reduced discharges, adsorption, radioactive decay, and improved waste management practices. Inside the site boundary, several radionuclide concentrations have exceeded the EPA maximum contaminant levels for drinking water. Outside the site boundary, all contaminant levels measured have been below the EPA levels (DOE 1995b).

INEL site vegetation includes saltbrush deserts, juniper woodlands, native grasslands, big and low sagebrush, and riparian communities. Big sagebrush is dominant, covering approximately 80 percent of INEL (DOE 1996a). The USFWS National Wetlands Inventory maps show over 130 potential wetlands, most found near the rivers and associated playas. As of December 1994, at least one area at the Big Lost River sinks was found to meet the criteria for jurisdictional wetland delineation by the United States Army Corps of Engineers (DOE 1995b). In 1975, DOE designated most of INEL as a NERP (DOE 1995k).

Several migratory species use the INEL site for part of the year. Two federal-endangered and nine federal species of concern were identified as potentially occurring on the site. Two state-protected and ten state species of special concern also potentially occur on the site. No federal- or state-listed plant species were identified as potentially occurring. Eight plant species considered sensitive, rare, or unique are known to occur (DOE 1995b).

INEL contains paleontological fossil sites and numerous prehistoric archeological sites. As of June 1994, more than 100 cultural resource surveys have been conducted, and over 1,500 archeological resources have been identified. Over 700 of these resources are considered to be potentially eligible for NRHP. The Experimental Breeder Reactor-I is a national historic landmark. INEL contains many resources culturally important to the Shoshone-Bannock Tribes. These include not only cultural sites but also features of the natural landscape. In accordance with federal laws and in consideration of DOE's Native American policy, DOE has committed to additional interaction and exchange of information with the Shoshone-Bannock Tribes of the nearby

Fort Hall Indian Reservation and is developing procedures for consultation and coordination at INEL (DOE 1995b). INEL is included on the CERCLA National Priorities List.

The socioeconomic ROI is a 7-county area where over 95 percent of INEL's approximate 6,400 employees reside (DOE 1996a). The ROI labor force was 104,654 in 1991, and the 1990 population was 219,713 (DOE 1995b). About 2.5 percent of this population was Native American, and 5.5 percent was Hispanic (META/Berger 1995). The population within an 80-kilometer (50-mile) circle centered at Argonne National Laboratory-West (on the INEL site) contains 7 percent minority and 14 percent low-income. See Figure S-2 for the location of nearby tribal lands. Retail trade and educational services are the two largest employment sectors in the ROI, accounting for 17.6 percent and 11.4 percent of employment, respectively (DOE 1995b). In 1990, the per capita income for the ROI was $14,622 (META/Berger 1995).

DOE has entered into an agreement with the tribal governments representing the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation. This agreement is designed to enhance Tribal technical and scientific capability in the areas of environmental restoration, emergency preparedness and response, and management of cultural resources.

About 144 kilometers (90 miles) of paved public highway run through the INEL site. Railroads also serve the area, and a rail line into INEL connects the towns of Arco and Blackfoot.

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 0.2 LCFs. The population within this area was 120,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 2×10^{-7} percent chance of an LCF. The corresponding dose is below the NESHAP limit. In addition, DOE estimates no adverse health effects from any noncarcinogenic chemical contaminants (DOE 1995b).

4.2.4 Lawrence Livermore National Laboratory (LLNL)

LLNL includes the Livermore site, the adjoining Sandia National Laboratories, California site (SNL-CA), and the LLNL experimental test site (Site 300). The Livermore site is approximately 64 kilometers (40 miles) east of San Francisco, California, and about 5 kilometers (3 miles) east of Livermore, California. The SNL-CA site is located next to and south of the Livermore site. Site 300 is about 24 kilometers (15 miles) southeast of Livermore in the sparsely populated hills of the Diablo Range. Today, the major programs at LLNL include defense and related programs, laser fusion, laser isotope separation, biomedical and environmental research, and environmental restoration and waste management (META/Berger 1995).

The Livermore and SNL-CA sites are at the southeast end of Livermore Valley in southern Alameda County. Site 300 is in a mostly rural area of San Joaquin County. Land adjacent to LLNL is predominantly private and consists of agricultural, residential, and light/industrial lands, with a smaller portion of public lands (META/Berger 1995).

The water supply for LLNL is provided by San Francisco's Hetch Hetchy water system. The current site load for water is 2,714,000 liters (717,000 gallons) per day and the maximum capacity is 9.54 million liters (2.52 million gallons) per day. The Pacific Gas and Electric Company and the Western Area Power Administration supply power to LLNL. The current site load is 61 megawatts. The maximum capacity is 100 megavolt-amperes (META/Berger 1995).

The Livermore site is in the San Francisco Bay Area Interstate Air Quality Control Region. This region has been classified as a nonattainment area for two criteria pollutants: CO and O_3. The Livermore site is in a Class II area, and any new sources of emissions must adhere to the increment standards for a Class II area (META/Berger 1995). Site 300 is located within the San Joaquin Valley Unified Air Pollution Control District. This area is classified as a nonattainment area for O_3 and PM_{10}. Several PSD Class I areas have been designated in the vicinity of LLNL, including Point Reyes National Wilderness Area, approximately 89 kilometers (55 miles) northwest of the Livermore site; Desolation National Wilderness Area; Mokelumne National Wilderness Area; Emigrant National Wilderness Area; Hoover National Wilderness Area; and Yosemite National Park. Since the promulgation of the PSD regulations in 1977, no PSD permits have been required for any emission source at the Livermore site (DOE 1996a).

The climate at LLNL and the surrounding region is classic Mediterranean with hot dry summers and cold wet winters. The average annual temperature is 12.5 degrees Celsius (54.5 degrees Fahrenheit). The temperature range at Site 300 is more extreme than at the Livermore site because of the higher elevation and pronounced relief (DOE 1996a). Annual precipitation at the SNL-CA ranges from 30 to 38 centimeters (12 to 15 inches) (META/Berger 1995).

All three sites lie within Seismic Zone 4 (DOE 1996a). The San Andreas fault system, the Sur-Nacimiento fault system, and the Coast Range thrust fault system are the major fault systems in the area. Along with local faults, these major regional faults are potential sources of ground motion at LLNL. In January 1980, an earthquake sequence on a local fault produced two earthquakes of magnitudes 5.5 and 5.6. These earthquakes caused structural damage at the Livermore and SNL-CA sites. Larger earthquakes on more distant faults, such as the San Andreas, do not substantially affect the hazard estimation for LLNL. The potential for surface faulting within the Livermore site is very low. Surface faulting at Site 300 in areas adjacent to the active Carnegie fault is possible (META/Berger 1995).

The main surface water features at the Livermore site are the Arroyo Las Positas and Arroyo Seco. Both stream channels are dry for most of the year. Two areas on the Livermore site are within the 100-year floodplains of these two streams; however, no existing on-site structures are within the 100-year floodplain. There are no perennial streams at or near Site 300. The canyons that dissect the hills and ridges at Site 300 drain into intermittent streams. The majority of these on-site streams drain to the south into Corral Hollow Creek, also intermittent, which flows east along the southern boundary of Site 300 in San Joaquin Valley. In addition to these streams, 24 springs and 2 vernal pools exist on-site. Some surface water discharge occurs from cooling towers and other process runoff areas (DOE 1996a).

Groundwater in the vicinity of the Livermore site is generally suitable as a domestic, municipal, agricultural, and industrial supply, with the exception of groundwater less than 90 meters (300 feet) deep. This groundwater is routinely monitored for radioactive and nonradioactive parameters. In 1993, the maximum concentrations of gross alpha, nitrate/nitrite, trichloroethylene, and tritium were above their water quality criteria or standard. The maximum concentrations found for tritium are in one local on-site well and pose no threat to water supplies. VOCs have also been detected in the on-site groundwater and in the area around the Livermore site. All site practices known to contribute VOCs to groundwater have been discontinued. LLNL is working with EPA and the State of California to identify appropriate remedial measures (DOE 1996a).

Two regional aquifers have been identified at Site 300. These are an upper water table aquifer of the Neroly Formation and a deeper confined aquifer also in the Neroly Formation (META/Berger 1995). At Site 300, groundwater is sampled quarterly from inactive and active water supply wells and monitoring wells, and analyzed for radioactive and nonradioactive parameters. Maximum concentrations of arsenic, gross alpha, nitrate/nitrite, trichloroethylene, tritium, and uranium were above their water quality criteria or standard at least once in 1993. LLNL is investigating and identifying characteristics of groundwater contamination at Site 300. Several plumes of VOCs and tritium have been identified in shallow and deeper bedrock aquifers in this area and several adjacent off-site areas. LLNL is working with the EPA and the State of California to remediate these plumes (DOE 1996a).

Fifty-nine federal- and state-listed threatened, endangered, and other special status species may be found on and in the vicinity of the Livermore site. Ten of these species have been observed on the site, including the federal-listed bald eagle (*Haliaeetus leucocephalus*). Thirty federal- and state-listed threatened, endangered, and other special status species have been observed on Site 300, and an additional 32 may be found on and in the vicinity of the site. These species include the federal-listed San Joaquin kit fox (*Vulpes macrotis mutica*), American peregrine falcon (*Falco peregrinus anatum*), large-flowered fiddleneck (*Amsinckia grandiflora*) and bald eagle; and the federal-proposed Alameda whipsnake (*Masticophis lateralis euryxanthus*) and California red-legged frog (*Rana aurora draytoni*). Although suitable habitats for several of the other listed species exist on-site at LLNL, potential occurrence of most of the other species is minimal due to the lack of suitable habitat (DOE 1996a). No critical habitat for threatened or endangered species exists at LLNL (META/Berger 1995).

Since 1974, several archeological investigations have taken place at the Livermore site and Site 300. No prehistoric sites have ever been located at the Livermore site. A preliminary investigation at the Livermore site in 1992 explored the historic significance of World War II-era buildings and developed a potential context for initial consideration of the distinguished technical and scientific resources of LLNL. Cultural resource investigations at Site 300 have resulted in the discovery of 7 prehistoric sites, 21 historic sites, and 1 with elements of each. Of these, 24 are officially recorded, but no evaluations to determine site significance have been performed. Sacred and important Native American resources that might be found in the vicinity of LLNL include burials, cremations, vision quest sites, and traditional-use areas. Initial consultation with Native American groups to determine important resources has begun (DOE 1996a). LLNL is included on the CERCLA National Priorities List.

Four counties comprise the economic ROI in which 97.2 percent of the approximate 7,850 employees at the Livermore site and Site 300 employees reside. In 1990, the population in the ROI was 2,952,000. The population in the ROI is predominantly White (69 percent), and approximately 8.4 percent of the families were living below the poverty level in 1989. In 1991, the unemployment rate for the ROI was 9.3 percent. The 1990 per capita income in the ROI was $21,099. The dominant industries in the ROI include services, government, manufacturing, and retail, which account for 68.8 percent of total earnings (META/Berger 1995).

LLNL is serviced by Interstate-580, Interstate-5, and Interstate-680. South Vasco Road and Greenville Road, both of which are accessed from Interstate-580, service the Livermore site from the north. Patterson Avenue and East Avenue provide access to the Livermore site from the east and west. The Southern Pacific Railroad and the Western Pacific Railroad are the primary providers of rail service to the LLNL region (META/Berger 1995).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 9 x 10^{-3} LCFs. The population within this area was 6,300,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 3 x 10^{-6} percent chance of an LCF. The corresponding dose is below the NESHAP limit. The impact to the LLNL worker population from operations in 1994 was estimated to be 7.3 x 10^{-3} LCF (DOE 1996a).

4.2.5 Los Alamos National Laboratory (LANL)

LANL is located in north-central New Mexico, 97 kilometers (60 miles) north-northeast of Albuquerque, New Mexico, and 40 kilometers (25 miles) northwest of Santa Fe, New Mexico. The 11,300-hectare (28,000-acre) LANL site and adjacent communities are situated on the Pajarito Plateau (DOE 1995i). Since its inception in 1943, LANL's primary mission has been nuclear weapons research and development and related projects (META/Berger 1995). The land surrounding LANL is largely undeveloped, and large tracts of federal land surrounding the site are managed by the United States Forest Service, Bureau of Land Management, National Park Service, and Los Alamos County.

Three DOE-operated well fields provide an average of 15.5 million liters (4.1 million gallons) per day for LANL. Electricity usage in 1993 was 68 megawatts (META/Berger 1995).

LANL and its surrounding counties are considered attainment areas with respect to applicable NAAQS. The criteria pollutants make up approximately 79 percent of the stationary source emissions at LANL. Toxic and other hazardous pollutants represent the remaining 21 percent of the stationary source emissions. One PSD Class I area, Bandelier National Monument's Wilderness Study Area, borders LANL to the south. Since promulgation of regulations, no PSD permits have been required for any emissions source at LANL (DOE 1996a).

Los Alamos has a semiarid, temperate mountain climate. The annual average temperature at LANL is 8.9 degrees Celsius (48.1 degrees Fahrenheit) (META/Berger 1995). The average annual precipitation is 48 centimeters (18.7 inches) but is quite variable from year to year. Approximately 36 percent of the annual precipitation normally occurs from thunderstorms during July and August (DOE 1995i).

LANL is located on the Pajarito Plateau, which lies between the Jemez Mountains on the west and the Rio Grande on the east. Deep southeast-trending canyons, separated by long, narrow mesas, dissect the surface of the plateau (DOE 1995i). Studies have determined that the area has three active faults. The strongest earthquake in the past 100 years within a 80-kilometer (50-mile) radius had an estimated magnitude of 5.5 to 6 measured on the Richter scale and a Modified Mercalli Intensity of VII (META/Berger 1995). The site lies within Seismic Zone 2 (DOE 1996a), as established by the Uniform Building Codes.

All groundwater and surface water drainages from the Pajarito Plateau flow toward the Rio Grande. On-site tributaries to the Rio Grande include 14 drainage areas that pass through or start at LANL. Three of the canyons receive treated industrial or sanitary effluent. Surface water in these canyons is principally ephemeral and is not a source of municipal, industrial, or agricultural water supply. Regional, perimeter, and on-site surface waters are monitored to provide routine surveillance on the effect of LANL operations on water quality (META/Berger 1995). Surface water in the Los Alamos area principally occurs as short-lived or intermittent reaches of streams.

The overall flood risk to LANL is low because nearly all the structures are located on the mesa tops, from which runoff drains rapidly into the deep canyons (DOE 1996a).

Groundwater in the LANL area occurs in four modes: shallow alluvium in canyons, perched water, the unsaturated zone between the surface and the main aquifer, and the main aquifer (DOE 1995i). Nearly all groundwater used at LANL originates from deep wells that produce water from the main aquifer. Under LANL are Class II aquifers, which provide current sources of drinking water and have other beneficial uses. Most of the wells in the Pajarito Plateau yield fresh water (total dissolved solids less than 500 milligrams per liter), although some wells east of the site have a higher total dissolved solids content (1,000 milligrams per liter or more). The primary, secondary, and radiochemical groundwater quality, as measured from wells and springs in the main aquifer, are below the DOE derived concentration guides or the New Mexico standards applicable to a DOE drinking water system. LANL and the nearby communities are entirely dependent on groundwater for their water supply (DOE 1996a).

The predominant vegetative communities at LANL are ponderosa pine, piñon-juniper, and juniper-grassland. LANL was designated a NERP in 1976 (META/Berger 1995). Most LANL wetlands occur in canyons. Wetlands have developed in the vicinity of some outfalls serving LANL facilities. Thirty-four federal- or state-listed threatened, endangered, and other special status species may be found in the vicinity of LANL. Five of these species have been observed at LANL, but only one has been found to nest there and occupy the site year-round. Critical habitat for the Mexican spotted owl (*Strix occidentalis lucida*), a federally threatened species, exists at LANL and in areas bordering the northern and western boundaries of LANL (DOE 1996a).

Approximately 75 percent of LANL has been inventoried for cultural resources. More than 1,000 prehistoric sites have been recorded, and approximately 95 percent of these sites are considered eligible or potentially eligible for inclusion in the NRHP. Two areas in the vicinity of LANL have been established as NRHP sites or districts: Bandelier National Monument and Puye Cliffs Historical Ruins. Many of these cultural resources are of special importance to Native Americans in the area. Consultations with local Native Americans to identify any such cultural resources have been conducted in the past and are ongoing. More than 40 historic resources have been recorded at LANL, and about 90 percent of the resources are considered eligible or potentially eligible for the NRHP, based on their association with the broad historic theme of the Manhattan Project and initial nuclear production (DOE 1996a).

Three counties comprise the economic ROI in which 94.7 percent of LANL's 9,700 employees reside. In 1990, the population in the ROI was 152,300. The population in the ROI is predominately White (79.8 percent) and 12.1 percent of the families are below the poverty level (META/Berger 1995). The 1994 unemployment rate in the ROI was 6.2 percent, and the per capita income in 1993 was $17,689. The service sector accounts for 31 percent of the nonfarm private sector employment in the ROI (DOE 1996a).

DOE has entered into an agreement with Tribal governments representing the Pueblos of Santa Clara, Cochiti, Jemez, and San Ildefonso. The purpose of this agreement is to build Tribal technical and scientific capability in environmental restoration and waste management and to assist the Tribes in participating in DOE decision making.

LANL is served by U.S. 84 and U.S. 285, which link Los Alamos to Santa Fe, New Mexico. U.S. 502, which can be accessed by U.S. 285 from Santa Fe, also services LANL. The nearest railway access is south of Santa Fe in Lamy, New Mexico (META/Berger 1995).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 2 x 10^{-3} LCFs. The population within this area was 220,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 4 x 10^{-4} percent chance of an LCF. The corresponding dose is below the NESHAP limit. Two epidemiological studies have recently been conducted in the LANL area. The most recent study presented an increased incidence of thyroid cancer in residents of Los Alamos county compared to the rest of New Mexico (DOE 1996a).

4.2.6 Mound Plant (Mound)

Mound is located in west-central Ohio, in Montgomery County, within the city limits of Miamisburg, Ohio, about 16 kilometers (10 miles) south-southwest of Dayton, Ohio (Holdren et al. 1995). Mound occupies about 124 hectares (306 acres) (DOE 1979) and is situated on the highlands overlooking the Great Miami River. Until December 1991, Mound manufactured nonnuclear components and tritium-containing components for nuclear weapons. Mound's current mission is environmental restoration and economic development (DOE 1994b). Land use and cover within the vicinity of the Mound site is primarily residential and woodland, and on the site itself there are heavily wooded areas (Holdren et al. 1995).

The Air Quality Control Region comprising the facility has been classified as attainment of the NAAQS for NO_2, SO_2, and lead. However, DOE lists Montgomery County as nonattainment for O_3 and TSP (DOE 1995e). Operations at Mound emitted a wide variety of nonradioactive contaminants, such as organic solvents, acids, and metals (DOE 1989). Various radioactive contaminants such as Pu-238 and tritium were also released. The site is also a source of radionuclides due to resuspension of contaminated soils related to past practices. Recorded levels of these contaminants are well below DOE guidelines (DOE 1995e).

Tornadoes may touch down along short and narrow paths, but are infrequent in the region. Tornado wind speeds of 146 kilometers (90 miles) per hour or greater have an annual probability of occurrence of one in one thousand. Tornadoes with wind speeds exceeding 368 kilometers (227 miles) per hour have an annual probability of one in one million (DOE 1995e).

The major surface water feature in the area is the Great Miami River, located approximately 450 to 600 meters (1,500 to 2,000 feet) west of the site. The tributary valley between the two main hills contains a drainage ditch, the only perennial stream within Mound boundaries (Holdren et al. 1995). Surface water quality in the vicinity of Mound is satisfactory, with radioactivity levels far below established limits (DOE 1995d).

The major aquifer in the area, the Buried Valley Aquifer (also called the Great Miami Aquifer), is the major source of the area's potable water. Typically, groundwater occurs 6 to 8 meters (20 to 26 feet) below ground surface in the valley. The bedrock also contains groundwater but cannot provide a reliable source. The glacial tills overlying the bedrock may also contain perched water zones but are generally too thin to act as a water supply (Holdren et al. 1995). There has been minor contamination of the groundwater by Mound activities. Tritium and plutonium have been detected in the Miamisburg water supply at levels far below regulatory limits. Some on-site groundwater VOCs exceed EPA levels; however, off-site concentrations are far lower, with none exceeding EPA levels (DOE 1995d).

The site lies within the range of the Indiana bat (*Myotis sodalis*), a federally-listed endangered species. However, the bat has not been seen on-site, and habitats hosting the bat are not present at

the site. A single specimen of the Inland rush (*Juncas interior weig*), a state-endangered plant species, was found but it is not considered a viable breeding population. No other rare or endangered species have been found on the site (DOE 1995d).

The only historic landmark in the vicinity of the site is the Miamisburg Mound, an ancient mound located 120 meters (390 feet) east-southeast of the site. It is believed to be a burial place of a member of the Adena culture of Mound Builders which inhabited the Ohio region in prehistoric times (DOE 1979). The site itself does not contain any properties listed or eligible for the NRHP (DOE 1995d).

The city of Miamisburg is largely residential, with limited commercial and industrial development. The 1990 population of the city was 17,770. Within an 8-kilometer (5-mile) radius of the site, the population is estimated to be 76,061, based on 1988 figures (DOE 1995d). The population rises to several hundred thousand within a 16-kilometer (10-mile) radius and to over one million within a 32-kilometer (20-mile) radius. The facility employs about 1,200 people, the majority of whom live either in Miamisburg or in immediately adjacent areas (DOE 1979).

Area routes include the Dayton-Cincinnati Pike, 0.6 kilometers (0.4 miles) west of Mound; State Route 725, 1.4 kilometers (0.9 miles) to the north; and Interstate-75, 5 kilometers (3 miles) to the east. The tracks of the Penn Central Railroad roughly parallel the western boundary of the site at distances ranging from approximately 15 to 60 meters (50 to 200 feet) (DOE 1979).

There are 22 known radioactively contaminated soil areas on-site and one area off-site. Sediments in the Great Miami River also contain levels of radioactive material that are higher than background levels for the surrounding area. There are also approximately 100 areas on-site that are either known or suspected to be contaminated with nonradioactive hazardous substances (DOE 1989).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 1×10^{-3} LCFs. The population within this area was 3,000,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 2×10^{-6} percent chance of an LCF. The corresponding dose is below the NESHAP limit.

4.2.7 Nevada Test Site (NTS)

NTS occupies 3,500 square kilometers (1,350 square miles) of desert valley and Great Basin mountain terrain in southern Nevada, 105 kilometers (65 miles) northwest of Las Vegas, Nevada. Limited access areas, including the Nellis Air Force Base Bombing and Gunnery Range and the Tonopah Test Range, surround the site. The NTS has been the primary location for testing the nation's nuclear explosive devices since 1951 (META/Berger 1995).

Fourteen on-site wells supply an average of 5.15 million liters (1.36 million gallons) of water per day. The Nevada Power Company supplies electricity to NTS. The current site load is 30 megawatts (META/Berger 1995).

NTS is designated as an attainment or unclassified area with respect to all applicable NAAQS. Two PSD Class I areas in the vicinity of NTS are Grand Canyon National Park, Arizona, approximately 193 kilometers (120 miles) to the southeast and Sequoia National Park, California, located approximately 169 kilometers (105 miles) to the west-southwest of the site. Since

promulgation of regulations, no PSD permits have been required for any emissions source at NTS (DOE 1996a).

NTS is in an area of moderate historic seismicity on the southern margin of the Southern Nevada East-West Seismic Belt in Seismic Zones 2 and 3. Since about 1848, more than 4,000 earthquakes have been recorded within a 242-kilometer (150-mile) radius of NTS. Most of these were minor events with Richter magnitudes of less than 5.5 (DOE 1995k). The Yucca fault is the only active fault on NTS within the underground nuclear testing area. The Rock Valley fault near the southern boundary of NTS has been the most active fault since 1990. (META/Berger 1995).

There are no continuously flowing streams at NTS. The only permanent on-site water bodies are ponds associated with wastewater disposal and springs. Sanitary wastewater influents to ponds and lagoons are regulated under a series of state permits. Surface water bodies at NTS are routinely monitored for radioactive and nonradioactive parameters, and off-site surface water bodies and springs are also monitored for radionuclides (META/Berger 1995).

NTS has three general water-bearing units, and all are classified as Class IIA or Class IIB aquifers. Groundwater is the only source of drinking water in the NTS area. On-site wells are routinely monitored for radioactive and nonradioactive parameters, as required by the Safe Drinking Water Act, State of Nevada regulations, and DOE orders. Off-site groundwater is routinely monitored at 22 locations for radionuclides. Only three locations have evidenced detectable tritium levels on a consistent basis. In all three cases, the tritium activity has been less than 2 percent of the primary maximum contaminant level for tritium (20,000 picocuries per liter) (META/Berger 1995).

Thirteen federal- and state-listed threatened, endangered, and other special status species are present in the vicinity of NTS. The desert tortoise (*Gopherus agassizii*) is the only resident federal-listed endangered species known to inhabit NTS. No critical habitat for threatened or endangered species exists on NTS (DOE 1996a).

Approximately 6 percent of NTS has been inventoried for cultural resources, and over 1,200 prehistoric sites have been recorded (DOE 1996a). Many of these sites may be eligible for listing on the NRHP. The only historic site that is currently listed is the Sedan Crater, which was created as part of the Plowshare Program to identify peaceful uses for nuclear explosions. Native American resources include ceremonial sites, petroglyphs, and traditional-use areas. Native Americans view many natural resources at NTS as cultural resources (DOE 1995k).

Two counties comprise the economic ROI in which 97 percent of the 1,600 NTS employees live. The ROI population totaled 865,144 in 1992 (DOE 1996a). The population in the ROI is predominately White (81.5 percent), and in 1989, 7.5 percent of the population was below the poverty level (META/Berger 1995). During 1994, unemployment in the ROI was 6.1 percent. The 1993 per capita income in the ROI was $20,561. The service sector is the major economic sector in the ROI, with over half on the region's nonagricultural activity (DOE 1996a).

DOE has entered into two separate agreements with Consolidate Group of Tribes and Organizations to foster a government-to-government relationship and to encourage involvement in programs associated with NTS operations. This group is composed of 17 Tribes representing three ethnic groups (Western Shoshone, Owens Valley Paiute, and Southern Paiute) from Arizona, California, Nevada, and Utah, with cultural or historic ties to NTS.

Vehicular access to NTS is provided by U.S. Route 95 from the south and off-road access via State Route 375 from the northeast (DOE 1995b). Interstate-15 is the major transportation route in the region (META/Berger 1995). The major railroad in the area is the Union Pacific, which runs through Las Vegas and is located approximately 80 kilometers (50 miles) east of the NTS.

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 0.3 LCFs. The population within this area was 33,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 8 x 10^{-6} percent chance of an LCF. The corresponding dose is below the NESHAP limit. Epidemiologic studies on groups surrounding NTS have concentrated on health effects in soldiers and children associated with nuclear testing rather than operational emissions. Results are contradictory regarding the observed leukemia incidence and deaths in exposed children (DOE 1996a).

4.2.8 Oak Ridge National Laboratory (ORNL)

ORNL is part of the 13,980-hectare (34,545-acre) Oak Ridge Reservation (ORR) located 32 kilometers (20 miles) west of Knoxville, Tennessee, in the rolling terrain between the Cumberland Mountains and Great Smoky Mountains. The primary mission of ORNL is basic and applied research, technology development, and special DOE research. ORR also contains the Y-12 plant whose missions include dismantling nuclear weapons components, maintaining nuclear production capability and stockpile support, and providing storage for nuclear materials; and the K-25 site, which presently serves as an operations center for environmental restoration and waste management programs. The K-25 site formerly provided enriched uranium for United States nuclear weapons (DOE 1995k). The land surrounding ORR is primarily rural, dominated by agricultural and residential land (Holdren et al. 1995).

The Clinch River provides an average of 69.3 million liters (18.3 million gallons) of water per day to ORNL and ORR. The Tennessee Valley Authority provides electric power. The current site load is 116 megawatts (META/Berger 1995).

As of 1991, the area within the Air Quality Control Region was designated as attainment with respect to all NAAQS for criteria pollutants. The Great Smoky Mountains National Park is the only PSD Class I area in the vicinity of ORNL. Since the promulgation of regulations, no PSD permits have been required for any emissions source at ORNL (DOE 1995k).

Winters are generally mild and summers are warm, with few extremes in precipitation, temperature, or winds (DOE 1995k). Summer thunderstorms are frequent. Tornado occurrence in the general region averages about 0.5 per year (DOE 1995j). The annual average temperature is 14.2 degrees Celsius (57.5 degrees Fahrenheit). The annual average precipitation is 139 centimeters (55 inches) (DOE 1995k).

The topography, primarily ridge-and-valley, is part of the Tennessee Valley and Ridge Province of the Southern Appalachian fold and thrust belt (Holdren et al. 1995). There is no evidence of active faulting in the immediate area, although many inactive faults are present at ORNL (DOE 1995k). Regionally, earthquake frequency averages 1-2 per year (META/Berger 1995). Since 1812, at least 26 earthquakes with a Modified Mercalli Intensity of II to VI have been recorded in the area (DOE 1995j). ORNL lies within Seismic Zone 2, indicating that the probability of future seismic damage is low to moderate (META/Berger 1995). The site lies on moderately-well to well-drained

soils. Soil erosion has ranged from light to severe, and the present erosion potential is high in some areas (DOE 1995k). The typical soil in the area is a reddish-brown clay (DOE 1995h).

The Clinch River and its tributaries are the major surface water features of the area (Holdren et al. 1995). ORR streams receive effluents from treated sanitary wastewater, industrial discharges, cooling water blowdown, stormwater, surface water runoff, and groundwater. Substantial cleanup activities are required both on-site and off-site (DOE 1995k).

Although groundwater occurs in all formations that outcrop at ORNL and ORR, three major hydrologic units are present. Mechanisms and rates of flow appear to be controlled by topography, structure, and lithology (Holdren et al. 1995). There are no Class I sole-source aquifers beneath the site. Very little groundwater is used; only one supply well exists on ORR. Background groundwater quality is generally good in the near surface aquifer zones and poor at greater depths due to high total dissolved solids. Hazardous chemicals and radionuclides from weapons production process activities have contaminated groundwater in some areas. The contaminated sites include past waste disposal sites, waste storage tanks, spill sites, and contaminated inactive facilities (DOE 1995k). ORR is included on the CERCLA National Priorities List.

ORR is heavily forested, with pine and pine-hardwood forest being the most extensive plant community, followed by oak-hickory forest (DOE 1995k). Approximately 20 percent of the site consists of wetlands; half of this is bottomland forest and half is pothole wetlands (META/Berger 1995). Approximately 5,500 hectares (13,590 acres) has been designated as a NERP (DOE 1995j). There are 88 federal- and state-listed threatened, endangered, and other special status species that have been identified on or in the vicinity of ORR. However, no critical habitat for threatened or endangered species exists on ORR (DOE 1995k).

More than 20 cultural resource surveys have been conducted on ORR. Over 45 prehistoric sites have been recorded, one site has been included in the NRHP, and several more are considered eligible. More than 240 historic resources have been recorded, and 50 of those sites may be eligible for the NRHP. The Graphite Reactor is a National Historic Landmark. There are also some resources that may be sensitive to Native American groups, including historic burial mounds, camps, quarries, chipping stations, limited activity locations, and shell scatters (DOE 1995j).

Four counties comprise the economic ROI in which about 92 percent of ORR employees live. The 1990 population of this ROI was about 489,000 (DOE 1995b). Minorities comprised 8.4 percent of this population, while 10.6 percent was below the poverty level (META/Berger 1995). The unemployment rate was 5.9 percent in 1991, and the per capita income was almost $17,000 (DOE 1995h). Major economic sectors include services, with over 26 percent of the region's total private sector nonagricultural activity; manufacturing (19 percent); and retail trade (17 percent) (DOE 1996a).

Interstate-40, located 2.4 kilometers (1.5 miles) south of the ORR boundary, provides the main access to the cities of Nashville and Knoxville, Tennessee. Interstate-75, located 24 kilometers (15 miles) south of the site serves as a major route to the north and south. Several state routes provide local access and form interchanges with Interstate-40. Railroad service is also available in the area (DOE 1995b).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 2×10^{-2} LCFs. The population within this area was 940,000. The annual dose from airborne radionuclides to the MEI during

1994 would result in a 9 x 10^{-5} percent chance of an LCF. The corresponding dose is below the NESHAP limit. Analysis of demographic data for communities surrounding ORNL indicates that if there were any adverse health effects to nearby communities, they would not disproportionately affect minority or low-income populations (DOE 1996a).

4.2.9 Rocky Flats Environmental Technology Site (RFETS)

RFETS covers almost 17 square kilometers (7 square miles) in northern Jefferson County, Colorado. The site is located east of the foothills of the Rocky Mountains, approximately 25 kilometers (16 miles) northwest of Denver, Colorado. RFETS is situated in a generally rural area with some ranches and industrial facilities nearby. Before January 1992, RFETS's primary mission was to produce nuclear weapon components from plutonium and other metals. The mission has now changed to decontamination and decommissioning, and the primary focus of the activities at RFETS is currently on environmental remediation and waste and materials management (META/Berger 1995).

The Denver Water Board from the Ralston and Gross Reservoirs provides the water supply for RFETS. Water is treated on-site at a plant with a maximum capacity of 3.8 million liters (1 million gallons) per day. The current site load for the treatment plant is 1.03 million liters (272,000 gallons) per day. The Public Service Company of Colorado supplies power to RFETS. The current site load for electricity is 18.3 megawatts (META/Berger 1995).

RFETS is located in an Air Quality Control Region that is a nonattainment area for the NAAQS criteria pollutants CO, O_3, and PM_{10} and an attainment area for the remaining criteria pollutants, SO_2, NO_2, and lead. Because the site is in a Class II PSD area, any new emission sources would have to adhere to the increment standards for a Class II area. The nearest Class I PSD area is Rocky Mountain National Park, approximately 50 kilometers (30 miles) northwest of RFETS (META/Berger 1995).

The climate in the area is semiarid. July is the warmest month, with daily maximum and minimum temperatures averaging 31 degrees Celsius (88 degrees Fahrenheit) and 15 degrees Celsius (59 degrees Fahrenheit), respectively. January is the coolest month, with daily maximum and minimum temperatures averaging 6 degrees Celsius (43 degrees Fahrenheit) and -9 degrees Celsius (16 degrees Fahrenheit), respectively. Annual precipitation is approximately 39 centimeters (15 inches), with about 80 percent falling from April through September (Holdren et al. 1995).

The topography at RFETS is generally flat except for areas along three creeks. Seismic activity in the area is low. An earthquake with a maximum horizontal acceleration of 0.21 gravity has an annual probability of occurrence of 1 in 5,000. The surface soils at the site are moderately deep, well-drained clay, cobbly clay, and sandy loams, with moderate-to-low permeability. Twenty-nine on-site locations monitor soil for plutonium contamination (META/Berger 1995).

There are five ephemeral streams at RFETS that form a west-to-east surface drainage pattern. The primary source of flood potential is from flash flooding in these streams; however, most facilities are located outside the 500-year floodplain. The site has seven National Pollutant Discharge Elimination System (NPDES) permitted outfalls, three of which discharge to surface waters that flow off-site. In 1992, only one case was reported in which the NPDES permit limits were exceeded, and this was for low pH at the wastewater treatment plant. Surface water is also monitored for radioactive and nonradioactive parameters in 3 on-site detention ponds. Monitoring of local drinking water supplies was discontinued in October 1992 (META/Berger 1995).

Groundwater systems at RFETS consist of a shallow, unconfined system in the Rocky Flats Alluvium and valley fill, and a confined system in the deeper sandstone units within the underlying bedrock. Recharge is from rainfall, snowmelt, leakage from other aquifers, and percolation from streams, ditches, and reservoirs. Discharge is by seeps, springs, base flow to streams, and evapotranspiration. Groundwater also leaves the area as subsurface flow. No aquifers in the area are sole source aquifers under the Safe Drinking Water Act regulations. The results of 1992 groundwater quality monitoring indicate that the groundwater in the area contains elevated levels of several VOCs, several radionuclides, and other contaminants (META/Berger 1995).

The major terrestrial communities at RFETS are mesic-mixed and xeric-mixed grassland (mixed tall- and short-grass communities), reclaimed grassland, riparian woodland, complex deciduous woodland and bottomland shrubland, tall upland shrubland, tall marsh, short marsh, and wet meadow. Wetlands represent 3.9 percent of the plant communities at RFETS and comprise a total of 100 hectares (250 acres). There are 40 federal- and state-listed threatened, endangered, candidate threatened or endangered, and other special status species that are known to occur or may occur at RFETS (META/Berger 1995).

RFETS has no properties designated as National Historic Landmarks or listed in the NRHP. According to the Colorado Historic Society, portions of the site have been the subject of at least three cultural resource investigations. The historic cultural resources in the area are archeological sites or standing structures associated with homesteads and ranching. Many Native American groups historically occupied or traversed the foothills area around RFETS. Important sites, such as burials or vision quest locations, and several unidentified rock features and alignments that have been recorded on RFETS may be of concern to Native American groups (META/Berger 1995).

Five counties comprise the economic ROI in which 92.5 percent of the site's 3,500 employees reside. In 1990, the ROI population was 1,790,600. The population was predominantly White (86.2 percent) with 7.2 percent of the total population living below the poverty level. In 1991, the unemployment rate for the ROI was 4.5 percent, and the per capita income in 1990 was $20,961. The dominant industries in the ROI include services, manufacturing, government, transportation and public utilities. These account for 68.1 percent of total earnings (META/Berger 1995).

The site is well served by both road and rail. Interstate-70, Interstate-25, and State Highways 72 and 93 serve the area. The city of Denver is a major railway hub in the Rocky Mountain region. A Southern Pacific line, approximately 1.6 kilometers (1 mile) south of the site, is the rail line nearest the plant and provides access to Denver. The nearest major airport is in Denver (META/Berger 1995).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 1×10^{-4} LCFs. The population within this area was 2,100,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 1×10^{-7} percent chance of an LCF. The corresponding dose is below the NESHAP limit. Radiological monitoring of animals shows no notable uptake of radionuclides in deer and no ecologically appreciable quantities of plutonium or americium in small animals (META/Berger 1995).

4.2.10 Savannah River Site (SRS)

SRS is located approximately 20 kilometers (12 miles) south of Aiken, South Carolina, bordering the State of Georgia at the Savannah River. DOE activities conducted at SRS involve tritium

recycling, support for the nation's space program missions, storage of plutonium on an interim basis, processing of backlog targets and spent nuclear fuel, waste management, and research and development (DOE 1995k).

Land use at SRS, which comprises 80,200 hectares (198,200 acres), is generally categorized as forest, water, or developed facility locations. A total of 77,400 hectares (191,300 acres) of SRS are undeveloped, of which 72 percent are forested. A majority of the woodlands, comprising 53 percent of the total site, are in revenue producing, managed timber production. DOE designated the entire SRS as a NERP, which allows the scientific study of the cypress swamp, southeastern pine, and hardwood forest ecosystems (DOE 1995k).

On-site wells provide an average of 6.1 million liters (1.6 million gallons) of water per day. The capacity of the system is 19 million liters (5 million gallons) per day. Both on-site and public supply sources provide electrical power. The existing site load is 130 megawatts (META/Berger 1995).

SRS is located near the center of the Augusta-Aiken Interstate Air Quality Control Region. The EPA classifies the areas within SRS and its surrounding counties as attainment areas with respect to the NAAQS for criteria pollutants. There are no known PSD Class I areas in the vicinity of SRS (DOE 1995k).

The SRS region is in a temperate climate with short, mild winters and long, humid summers. The average annual temperature is 19 degrees Celsius (66 degrees Fahrenheit); average daily temperatures vary from 3 degrees Celsius (38 degrees Fahrenheit) in January to 33 degrees Celsius (91 degrees Fahrenheit) in July. The average annual precipitation is 126 centimeters (50 inches) (DOE 1995k). Prevailing winds at SRS are from the southwest through west-northwest and from the northwest and east-northeast. The average annual wind speed is 5.7 meters per second (12.8 miles per hour) (DOE 1995k).

SRS is located in the Aiken Plateau portion of the Upper Atlantic Coastal Plain east of the Fall Line, a major physiographic and structural feature that separates the Piedmont from the Coastal Plain, in southeastern South Carolina. The soils at the site are mainly sandy and sandy loams. The site lies within a Seismic Zone 2 and is in an area where earthquakes capable of producing structural damage are not likely to occur. Probabilistic seismic hazard curves were developed for all DOE sites in the 1980s, and the results for SRS were that a peak acceleration of 0.19 gravity was associated with a probability of 2×10^{-4} per year (5,000-year return period). Since 1985, only three earthquakes, all of Richter magnitude 3.0 or less, have occurred in the immediate area of SRS (DOE 1995k).

The primary surface water feature is the Savannah River, which borders the site for approximately 32 kilometers (20 miles) to the southwest. There are six major streams that flow through SRS into the Savannah River, and approximately 190 Carolina bays scattered throughout the site. Carolina bays are naturally occurring land depressions that can hold water. The Savannah River and on-site streams are classified as fresh water suitable for primary and secondary contact recreation, as a source for drinking water supply following conventional treatment, fishing, and industrial and agricultural uses (DOE 1995k).

The most shallow aquifer at SRS is commonly referred to as the water table. Below the water table is the Congaree aquifer, and below it is the Cretaceous aquifer. Although there are variations, groundwater in the Cretaceous aquifer discharges predominantly along the Savannah River. The

Cretaceous aquifer is an abundant and important water resource for the SRS region. Some of the local cities, such as Aiken, also obtain groundwater from the Cretaceous, but most of the rural population in the SRS region gets its water from the Congaree or water table. Groundwater quality ranges from excellent (soft and slightly acidic) to poor (exceeding EPA drinking water standards for several constituents) in the vicinity of some waste sites. The Cretaceous aquifer is generally unaffected except for a relatively small portion of the site near existing waste treatment, storage, and disposal facilities that is contaminated with trichloroethylene. The Congaree aquifer is contaminated with trichloroethylene over a relatively small portion of the site in the northeast part of SRS and low levels of tritium in the General Separation areas. The water table is contaminated with solvents, metals, or low levels of radionuclides at several waste sites and facilities (DOE 1995k).

There have been five major plant communities identified at SRS. The loblolly-longleaf-slash pine community is the dominant community covering approximately 65 percent of the site. Swamp forests and bottomland hardwood forests are found along the Savannah River. SRS supports a diverse and abundant wildlife community, including 43 amphibian, 58 reptile, 213 bird, and 54 mammal species. SRS contains approximately 19,850 hectares (49,030 acres) of wetlands, most of which are associated with floodplains, streams, and impoundments. Sixty-one federal- and state-listed threatened, endangered, and other special status species have been identified at SRS. No critical habitat for threatened or endangered species exists on SRS (DOE 1995k).

More than 60 percent of SRS has received some level of cultural resources evaluation. More than 800 prehistoric sites have been identified, although fewer than 8 percent have been evaluated for eligibility to the NRHP. Approximately 400 historic sites have been identified within SRS, ten of which are eligible for the NRHP. Literature reviews and consultations with Native American representatives reveal that there are some concerns related to the American Indian Religious Freedom Act within the central Savannah River valley; however, no specific sites have been identified (DOE 1995k). SRS is included on the CERCLA National Priorities List.

Four counties in which 87 percent of all SRS employees reside compose the economic ROI. SRS currently employs approximately 16,300 persons (4.6 percent of the total regional economic area employment) (DOE 1995k). The total population in the ROI in 1990 was 460,028 with approximately 37 percent minority and 14 percent below poverty level. The ROI unemployment rate was 8.4 percent in 1991 (META/Berger 1995).

Interstate-20 is located approximately 29 kilometers (18 miles) northeast of SRS, providing the nearest interstate access to the site. State Routes 19, 64, and 125 are used by 40, 10, and 50 percent of the SRS commuters, respectively. SRS is served by more than 200 miles of primary roads on-site. Railroad service is also available through SRS (DOE 1995k).

The annual radiation dose to the population residing within 80 kilometers (50 miles) of the site from normal accident-free operations during 1994 would result in 8×10^{-3} LCFs. The population within this area was 620,000. The annual dose from airborne radionuclides to the MEI during 1994 would result in a 8×10^{-6} percent chance of an LCF. The corresponding dose is below the NESHAP limit.

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CHAPTER 5

CHAPTER 5
ENVIRONMENTAL IMPACTS

This chapter presents the results of environmental impact analyses for the Proposed Action, the three action alternatives, and the two no action alternatives. Environmental impacts of each alternative are discussed separately.

The environmental impacts that could result should the Proposed Action or any of the alternatives be implemented have been divided into four categories:

- Those impacts that would occur at the treatment sites due to the treatment and storage of transuranic (TRU) waste (for all alternatives), those that would occur both during and after long-term storage (for all alternatives except the Proposed Action), and those due to transporting the waste for treatment (for all alternatives except No Action Alternative 2)

- Those impacts that would occur due to transporting TRU waste from the treatment sites to the Waste Isolation Pilot Plant (WIPP) (except for the two no action alternatives)

- Those impacts that would occur due to waste handling, disposal, and decommissioning at WIPP (for the Proposed Action and all of the action alternatives) and the decommissioning of WIPP (for the no action alternatives)

- Those impacts that would occur due to releases associated with closure of the repository, long-term disposal of the waste, and any retrieval and recovery of the waste (for the Proposed Action and action alternatives)

As noted in Chapter 1, the Record of Decision (ROD) that followed the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990) stated that an analysis of the impacts of processing and handling TRU waste at the treatment sites would be conducted. The U.S. Department of Energy (DOE or the Department) has analyzed TRU waste processing and handling at its sites in the *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS) (DOE 1995f). Because estimates of TRU waste volumes and radionuclide and hazardous chemical inventories have been updated since publication of the Draft WM PEIS (as reported in Appendix A), a revised analysis of those impacts is included in this chapter. The following points highlight how impacts due to treatment and handling were assessed for this supplemental environmental impact statement (SEIS-II):

- Draft WM PEIS air quality impacts at the treatment sites have been incorporated by reference and summarized in SEIS-II. The impacts assessed in the Draft WM PEIS were considered appropriate because the proposed facilities would be the same number, type, and size as those proposed in SEIS-II. Though additional waste would be treated under some SEIS-II alternatives, the assumed treatment period is 35 years rather than the 10 years assumed in the Draft WM PEIS; therefore, the annual rate of treatment and annual air impacts would not increase.

- Estimated total life-cycle costs for the treatment and transportation of TRU waste to consolidation sites were based on the results presented in the Draft WM PEIS. Draft WM PEIS results were adjusted based on the updated TRU waste volumes used for SEIS-II. Total life-cycle costs for TRU waste treatment for the entire DOE Complex have been reported. Additional details on the estimated costs and the methods used for estimating these costs are presented in Appendix D.

- The impacts that may occur due to transporting TRU waste from the treatment sites to WIPP are based upon the consolidation and treatment alternatives presented in the Draft WM PEIS. The impacts were based upon the updated TRU waste volumes and radionuclide and hazardous chemical inventories reported in SEIS-II. Similarly, the impacts due to waste handling at WIPP also were based on these updated inventories. Details on the transportation analyses are presented in Appendix E.

- Industrial safety impacts due to treatment facility construction and operation were adjusted from those in the Draft WM PEIS. The adjustments were based upon the increased construction and operations time estimated under the SEIS-II alternatives. The Draft WM PEIS anticipated 10 years of planning and construction followed by 10 years of operations. SEIS-II analyses anticipated 35 years of operation for all alternatives. Those SEIS-II alternatives requiring shred and grout facilities or thermal treatment facilities also included a 12-year planning and construction period.

- Impacts to water resources and infrastructure (including wastewater, power, and roadways) may occur due to construction and operation of treatment and storage facilities. The potential impacts presented in the Draft WM PEIS are incorporated by reference and summarized in the following sections. No annual increases to these potential impacts would be anticipated due to differences between the inventories used for the Draft WM PEIS and SEIS-II. As decisions are made regarding the location of TRU waste treatment and storage facilities, site-specific National Environmental Policy Act (NEPA) reviews will be conducted, as appropriate.

COMPARING ALTERNATIVES

When comparing the impacts and costs of SEIS-II alternatives, it is important to recognize that disposal at WIPP would isolate waste for more than 10,000 years, while continuing storage in facilities would isolate waste for a maximum of 100 years before reconstruction or disposal (at WIPP or some other location) would be necessary. SEIS-II alternatives that would dispose of the largest amount of waste at WIPP would isolate more waste for a longer period of time than those alternatives that would dispose of less waste while storing the rest. The differences in the degree of waste isolation that DOE would achieve for a given set of costs and impacts should be considered by the reader when comparing alternatives because these differences, in some cases, are noteworthy.

For purposes of comparison, each alternative presents the impacts that potentially would occur (1) at treatment sites due to waste treatment and storage, (2) as a result of transporting TRU waste among the sites and to WIPP for disposal, (3) at WIPP from TRU waste handling and disposal operations, and (4) as a result of long-term releases from the closed repository or storage facilities.

As appropriate, potential environmental impacts are further identified as either resulting from the Basic Inventory or the Additional Inventory, each of which is composed of contact-handled (CH) TRU waste and remote-handled (RH) TRU waste (see Table 3-18 for a summary of the results).

- Impacts to ecological resources, land use, and cultural resources may occur due to construction and operation of treatment and storage facilities. The Draft WM PEIS reported that "major impacts to the resources at the sites are unlikely" because they can be avoided. The treatment facilities would need less than 1 percent of available land at proposed treatment site locations. Also, as decisions are made regarding the location of TRU waste treatment and storage facilities, site-specific NEPA reviews will be conducted, as appropriate.

- Human health impacts due to operating the treatment and storage facilities were adjusted from the impacts presented in the Draft WM PEIS, based upon updated TRU waste volumes and radionuclide inventories used in SEIS-II. Additional details on the methods used for adjusting these results are presented in Appendix B.

Potential environmental impacts from waste treatment, transportation, disposal, and releases following WIPP closure are presented below for the Basic Inventory and the Additional Inventory, each of which includes CH-TRU and RH-TRU waste. These results are presented to facilitate comparisons within and between alternatives (see Table 3-18 for a summary of the results). Sums and products of numbers in this chapter may not appear consistent because of rounding.

5.1 IMPACTS OF THE PROPOSED ACTION

The environmental impacts associated with implementation of the Proposed Action are detailed within this section. The Proposed Action would continue with the phased development of WIPP by disposing of TRU waste at the facility. Under the Proposed Action, WIPP would accept only newly generated defense TRU waste and that post-1970, defense TRU waste in retrievable storage. Throughout this document this inventory is referred to as the Basic Inventory. Waste would be treated to meet the Waste Acceptance Criteria (WAC); for purposes of analysis, the current planning-basis WAC were used (DOE 1996g). The waste would then be consolidated at the sites with the greatest volume of waste. The 10 sites for CH-TRU waste and four sites for RH-TRU waste are shown in Figure 3-1 in Chapter 3. Treatment at the sites and disposal at WIPP would occur over a 35-year operating period, through the year 2033. A more detailed description of the Proposed Action is given in Section 3.1.

5.1.1 Land Use and Management

DOE found in the Draft WM PEIS that the facilities needed to manage and treat TRU waste under the Proposed Action would require less than 1 percent of the land available for such activities at each proposed treatment site. In calculating the percentage, DOE removed from consideration any acreage with known cultural resource areas, sensitive habitats (including wetlands and wildlife management areas), prohibitive topographic features, and surface water. As a result, the Draft WM PEIS states that DOE would "have considerable flexibility in locating those facilities and impacts to on-site land use are estimated to be minimal." The Department would be able to minimize impacts to on-site land use and

ENVIRONMENTAL ANALYSES

The potential environmental impacts presented throughout Chapter 5 rely on information gathered during extensive site characterization and experimental programs and on the various scientific and engineering analyses performed by DOE since investigation of the WIPP site began in the late 1970s. Analyses used throughout SEIS-II are designed to provide conservative estimates of the reasonably foreseeable impacts that may occur.

Where appropriate, conservative assumptions are employed; thus, the analyses have a tendency to overestimate impacts. Typically, the analytical methods employed are examined in the appendices. A summary of the reasonably foreseeable impacts and key assumptions considered are presented throughout this chapter.

avoid conflicts with any off-site land use plans (DOE 1995f). The Department also would locate treatment facilities such that sensitive or inappropriate areas would be avoided. These sensitive or inappropriate areas would include flood plains, wetlands, known cultural resource areas, and the habitats of threatened or endangered species.

No substantial changes in this finding due to differences between the Draft WM PEIS and SEIS-II were determined. Though different inventories were used for each document, the Draft WM PEIS also assumed that the facilities would be large enough to treat all of the TRU waste in 10 years (for consistency of analysis across waste types); for SEIS-II, it was assumed that treatment would be completed within 35 years, as the waste is generated. Because the SEIS-II operations time would be three and one-half times longer than that anticipated under the Draft WM PEIS, the size and number of the treatment facilities needed for this SEIS-II alternative would be the same as those analyzed for the Draft WM PEIS. The specific location of treatment and waste management facilities within each site would be selected following additional site-wide or project-level NEPA reviews (for an explanation of tiered NEPA reviews, see Appendix B).

Under the Proposed Action, DOE would continue to occupy the land transferred to it by the WIPP Land Withdrawal Act (LWA). DOE would exercise its easements on land outside the WIPP withdrawal area for such uses as groundwater surveillance pads, signs, and transportation and utility corridors. The total aboveground disturbed area is estimated to be 20 hectares (50 acres), equal to the area of the current aboveground facilities. Additional construction at WIPP would be limited to its underground disposal area. During the closure period when a berm and permanent markers would be constructed over the underground disposal area, a total of 60 hectares (150 acres) would be disturbed.

Local WIPP land use includes grazing, recreation, and mining (Section 4.1.1). Currently, an area of 120 hectares (300 acres) is fenced and posted to prevent grazing, trespassing, or other uses. Other grazing areas within the withdrawn area are managed pursuant to the Land Management Plan. Access to a 590-hectare (1,454-acre) area of the WIPP site (the "Off Limits Area") is currently restricted to grazing (see Figure 4-2). Other areas are open to the public; however, various resources in the withdrawn area are protected. The LWA prohibits any surface or subsurface mining unrelated to the WIPP project, with the exception of two hydrocarbon leases. No activity is occurring under these leases, and the Department may acquire these leases in the future. The Proposed Action would continue these restrictions and land use management practices throughout the disposal and post-closure periods.

5.1.2 Air Quality

For TRU waste treatment, the only criteria pollutant postulated to exceed 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be carbon monoxide (CO) at the Rocky Flats Environmental Technology Site (RFETS) (17 percent) (see Appendix C). RFETS, Lawrence Livermore National Laboratory (LLNL), and Argonne National Laboratory-East (ANL-E) are in nonattainment areas for some of the pollutants. In those areas where air pollution standards are not met (nonattainment areas), activities that introduce new sources of emissions are regulated under the General Conformity Rule. In areas where air pollution standards are met (attainment areas), regulations for the Prevention of Significant Deterioration (PSD) of ambient air quality apply. In both cases, a permit is required for sources that will result in emissions equal to or greater than the limits set by pertinent regulations. No radiological, hazardous, or toxic air pollutants would exceed 10 percent of the applicable regulatory standard during normal accident-free treatment (DOE 1995f). Particulate matter less than or equal to 10 microns in diameter (PM_{10}) levels may increase during construction.

For SEIS-II, air quality impacts from operation of WIPP under the Proposed Action have been updated from those contained in Section 9.4.5 of the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) and referenced in SEIS-I (DOE 1990). SEIS-II air quality analyses also include information on the salt pile fugitive dust emissions (Tillman 1988b), emissions of particulates from the ventilation system (Tillman 1988a) not included in SEIS-I, and reflect fewer salt pile releases from bulldozer activity and fewer emissions from mining and support equipment because they would be smaller, electric, or would be used less often (Hollen 1996) than reported in the FEIS or SEIS-I.

The four criteria pollutants considered at WIPP were nitrogen dioxide (NO_2), sulfur dioxide (SO_2), CO, and PM_{10}. Volatile organic compounds (VOC), as ozone precursors, were also considered. Potential impacts were determined using the methods described in Appendix C. There would be only negligible releases of two other criteria pollutants, ozone and lead, under the Proposed Action. Principal emission sources of particulates from operation of WIPP under the Proposed Action are (1) exhaust from underground mining, (2) surface salt handling, (3) wind erosion of the salt pile, and (4) fuel combustion from two back-up diesel generators and mining and support equipment. Fuel combustion would be the principal source of NO_2, SO_2, and CO.

Estimates of criteria pollutant air quality impacts from WIPP disposal operations under the Proposed Action are provided in Table 5-1. WIPP would remain an attainment area for all criteria pollutants, and there would be no impact to nearby national parks (Carlsbad Caverns and Guadalupe Mountains) which are Class I attainment areas. Increases in annual concentrations of each analyzed pollutant would be small (less than 2 percent of the regulatory limit). Some 24-hour impacts could be, on a short-term basis, as high as 65 percent of regulatory limits (for NO_2) due primarily to use of backup generators. These estimates represent an upper limit to the 24-hour impacts owing to the conservative assumptions used in the modeling. These conservative assumptions included that low-velocity wind would blow directly at a receptor under stable atmospheric conditions, thus minimizing dispersion and maximizing concentrations. Calculated VOC releases (an ozone precursor) were compared to the New Mexico PSD regulation (Air Quality Control Regulation [AQCR] 707), a major source screening criteria for ozone (40 tons per year). Calculated VOC emissions (an ozone precursor) from waste disposed of in WIPP would not exceed 2 percent of this level. Radionuclide releases would be less than 0.1 percent of the limit specified in the National Emissions Standard for Hazardous Air Pollutants (NESHAP) (40 Code of Federal Regulations [CFR] 61, Subpart H).

Table 5-1
Impacts on Air Quality at WIPP Under the Proposed Action

Criteria Pollutant	Averaging Time	Concentration at Maximally Impacted Point of Unrestricted Public Access (μg per cubic meter)	Regulatory Limit (μg/cubic meter)	Percent of Regulatory Limit
PM_{10}	Annual	0.67	50[a]	1.3
	24-hour	85	150[a]	57
NO_2	Annual	0.28	84[b]	0.3
	24-hour	110	168[b]	65
SO_2	Annual	0.02	47[b]	0.05
	24-hour	8.5	234[b]	3.6
	3-hour	77	1,170[c]	6.6
CO	8-hour	110	8,900[b]	1.3
	1-hour	410	13,400[b]	3.1

[a] National primary ambient air quality standard (40 CFR Part 50).
[b] New Mexico ambient air quality standard (AQCR 201) corrected for altitude.
[c] National secondary ambient air quality standard (40 CFR Part 50) corrected for altitude.

The plans for decommissioning WIPP under the Proposed Action are described in Section 3.1.3.5. Potential air quality impacts could result from the construction of berms around and permanent markers in the surface area overlying the underground disposal area, dismantling all the aboveground structures on the site, and reclaiming the salt pile. Specifically, air quality impacts would be the result of fugitive dust and emissions from heavy-duty construction equipment typical of a large construction project. Reclaimed salt may be used to either close the shafts or as a base for the berm. Excess salt may be sold for other purposes and transported off-site by private carrier. Decommissioning would produce temporary increases in dust and other criteria pollutants but no substantial long-term impacts.

5.1.3 Biological Resources

Analyses conducted during the Draft WM PEIS determined that construction and operation of TRU waste treatment facilities should not have major adverse effects on populations of nonsensitive plant and animal species for two reasons: (1) no more than 11 hectares (28 acres) would be disturbed at any site, and (2) the habitats for these species are well established regionally near the proposed treatment sites. Site activities are not expected to affect ecosystem balance or biodiversity. Also, because so little land would be required for the waste management and treatment facilities, DOE would be able to locate the new facilities to avoid impacts to sensitive habitat areas (see Section 5.1.1 above).

Threatened and endangered species appear at all of the proposed treatment sites and could potentially be impacted; however, whether there would be impacts depends on the actual location of the facility at a particular site. Such species and their critical habitats would be avoided, and appropriate consultation, monitoring, and mitigation measures would be undertaken. Site selection would be conducted following site-wide or project-level NEPA review during which such impacts would be assessed. The Draft WM PEIS analyses also determined that terrestrial wildlife species were unlikely to be affected by airborne emissions from waste management or treatment facilities, or from spills of TRU waste into aquatic environments due to traffic accidents, although under the Proposed Action, more waste would be treated at these facilities than considered in the Draft WM PEIS and over a longer period of time.

Federally listed, threatened and endangered, and state-listed species occur in Eddy County and potentially at WIPP, although DOE has not observed threatened, endangered, or proposed species or critical habitats at the WIPP site during surveys conducted for recent biennial environmental compliance reports. DOE is conducting a survey to update the list of species at the site and will consult with these agencies once the survey is completed.

At WIPP, vegetation-monitoring data from 1989 through 1993 were consistent with those reported in SEIS-I (DOE 1990), which indicated no salt-related stress in vegetation except for that directly near the salt pile. At the salt pile, based on past observations, increased shrub cover near the salt cuttings is anticipated due to colonization by saline-tolerant species such as the fourwing saltbush (*Atriplex canescens*) (DOE 1995d). Throughout the WIPP site, however, no change in foliage was occurring at the time of SEIS-I, and recent environmental reports indicate that this is still the case (DOE 1991, 1992, 1993, 1994b, and 1995d). SEIS-I also reported a salt buildup in the soil below 75 centimeters (30 inches) but stated that it was not affecting the vegetation and that the buildup was not expected to continue. During disposal operations, the salt pile is anticipated to stabilize as a 12-hectare (30-acre) working pile, which would not affect the ecosystem balance. Salt tolerant plant species would replace less saline-tolerant species such as the black grama grass (*Bouteloua eriopoda*) and are not expected to affect site ecosystem balance or biodiversity (DOE 1994b).

Over 10 years of avian survey data at WIPP (from 1984 through 1994) have revealed no discernible impacts on densities and distributions of breeding birds due to activities in the areas adjacent to the surface facilities. The Cooperative Raptor Research and Management Program has reported no adverse effects to raptors from WIPP activities. In addition, no adverse effects to small mammals from WIPP operations have been reported (DOE 1995d). Negligible impact to plant and animal communities near the WIPP site would be expected because almost all of the proposed operations would be conducted underground or in areas already developed.

Decommissioning and closure of the WIPP site would result in the dismantling of all aboveground structures and reclamation of the area. These activities would affect approximately 60 hectares (150 acres), resulting in the loss of much of the plant community and avian and small mammal habitats within and near the area. DOE would return decommissioned lands used in the operation of WIPP to a stable ecological condition and maintain or enhance the ecological condition of wildlife habitat within the WIPP Land Withdrawal Area (DOE 1996b).

5.1.4 Cultural Resources

Because cultural resources at many of the treatment sites are eligible or potentially eligible for the National Register of Historic Places (NRHP), construction and operation of TRU waste management and treatment facilities could have an adverse effect. Site-level cultural resource surveys would be conducted and protection measures established, where necessary, when specific facility locations are proposed (DOE 1995f). These surveys would be part of site-wide or project-level NEPA reviews. Any Native American sacred sites and burial grounds would be avoided and appropriate consultation would be undertaken.

At WIPP, disposal surface activities and salt pile maintenance would take place within already disturbed areas of the Property Protection Area. Because no new construction of surface features would occur, impacts to cultural resource properties are not anticipated as part of the shipping, waste handling, or emplacement operations. Previous research of the site cultural resources has identified and evaluated individual properties and mitigated, as necessary, potential impacts from the construction of surface features in the Property Protection Area. No Native American sacred sites or burial grounds have been identified to date.

Activities undertaken in conjunction with closure and decommissioning under the Proposed Action, may have potentially adverse impacts on cultural resources, depending on the ultimate design of the permanent marking system and the berm. Two prehistoric archaeological sites, LA33179 and LA33180, are located within the proposed surface closure area. Both sites were evaluated as being potentially eligible for inclusion on the NRHP (DOE 1995d). Site LA33179 was subjected to surface collection of artifacts and subsurface testing in 1981 (DOE 1996b). Site LA33180 appears to be partially buried and may require testing and mitigation activities if important subsurface cultural deposits are present.

Measures for ensuring protection of known archaeological and historic resources, or others that may be inadvertently discovered during ground-disturbing activities, are discussed in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1996b). These measures include identifying, inventorying, evaluating, and treating cultural resources under the National Historic Preservation Act of 1966. DOE will avoid, to the maximum extent possible, sites found eligible for inclusion in the NRHP. Where avoidance is not possible, mitigation measures will be developed in consultation with the State Historic Preservation Office, Advisory Council on Historic Preservation, and the Bureau of Land Management (BLM).

5.1.5 Noise

According to the Draft WM PEIS, treatment facilities would probably be placed at industrial-type sites along high traffic volume corridors; therefore, treatment should not substantially increase ambient noise levels. Still, the Draft WM PEIS notes that sensitive receptors may be impacted. Site-specific noise impacts will be assessed in a site-wide or project-specific NEPA document when siting treatment facilities. Noise impacts due to waste transportation to or from the treatment sites would be less than noise levels near the WIPP site (discussed below). Under this alternative, all waste would travel to WIPP but only a portion of the waste would travel to or from each treatment facility.

Noise impacts at the WIPP site were initially evaluated in the FEIS (DOE 1980) which provided a qualitative evaluation of operational impacts that remains accurate for SEIS-II. The FEIS determined that an overall sound pressure level of 50 decibels might occur 122 meters (400 feet) from the Waste Handling Building due to normal operations. The noise should not be heard at the nearest residence. The FEIS also indicated that should all of WIPP's equipment be operated at once or its emergency generators tested simultaneously, the noise level may increase. However, the FEIS also states that the levels would typically be within acceptable limits as established by the U.S. Department of Housing and Urban Development (DOE 1980).

Under the Proposed Action, all truck transportation of TRU waste would travel through Carlsbad, New Mexico (see figures in Appendix E for routes). Waste from all of the sites east of the Mississippi River would arrive from the south on U.S. 285. Waste from all other sites would come from the north on U.S. 285, passing through Vaughn, Roswell, and Artesia, New Mexico, prior to arriving at Carlsbad. Trucks would arrive at random times throughout two WIPP working shifts. Impacts were estimated based on a maximum throughput of 50 TRUPACT-IIs and eight RH-72Bs per week, corresponding to a maximum of eight trucks per day. The increase in noise associated with this level of truck traffic would be negligible compared to the background noise level associated with existing automobile and truck traffic in Carlsbad and along the transportation corridors.

5.1.6 Water Resources and Infrastructure

Negligible impacts on water resources are expected at the treatment sites due to the Proposed Action. The Draft WM PEIS assessed water availability issues by identifying whether water needs during construction and operation of treatment facilities would increase by more than 1 percent at the DOE facilities proposed as treatment locations. Under this alternative, only Idaho National Engineering Laboratory (INEL), LLNL, and RFETS would have such increases. The increases would be 1.2, 2.8, and 2.1 percent, respectively, and could be accommodated by existing water supplies.

Although no off-site annual infrastructure impacts would be expected at the treatment sites, proposed TRU waste activities would affect on-site activities. The affected infrastructure elements analyzed were on-site transportation and the capacity of on-site water, power, and wastewater systems. Water and power were evaluated for both construction and operations; wastewater treatment was evaluated only for operations because construction wastewater was assumed to be negligible.

Under the Proposed Action, only the Hanford Site (Hanford) would show an increase in on-site demand for wastewater treatment that would exceed 5 percent of current demand (5.9 percent). Major impacts to water resources at the sites would be unlikely for treatment of TRU waste (DOE 1995f).

Minor impacts to the on-site transportation infrastructure under the Proposed Action might occur. These impacts would be the result of an increase in on-site employment of 6 percent at Hanford and INEL and 7 percent at Los Alamos National Laboratory (LANL). Impacts to the off-site transportation infrastructure are not anticipated because population increases would not exceed five percent (DOE 1995f).

Disposal operations at WIPP would result in increased vehicle traffic from both the site work force and waste transport vehicles, but no new construction of roads or rail lines by DOE for waste transport is anticipated. Negligible annual infrastructure impacts would be expected at WIPP under the Proposed Action. Existing water supply and sewer capabilities, and existing and planned power and roadway resources would be able to accommodate proposed disposal operations.

5.1.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts under the Proposed Action are presented in the following subsections.

5.1.7.1 Life-Cycle Costs

Life-cycle costs under the Proposed Action are presented in Table 5-2 for three areas: waste treatment facilities, waste transportation, and WIPP disposal operations. Waste treatment facility costs include construction, operations and maintenance (O&M), and decontamination and decommissioning (D&D) at the TRU waste treatment sites. These sites would process, treat, and package waste over a period of 35 years to meet planning-basis WAC. The waste treatment facility costs, including storage costs for the excess RH-TRU waste, are estimated to be $11.8 billion, or an annualized cost of $340 million (in 1994 dollars). The waste transport costs include consolidating waste volumes at the 10 sites and then shipping the treated volumes to WIPP for disposal over the 35-year period. The waste transport costs are estimated to be $1.6 billion, or an average of $45 million per year. Finally, the WIPP site life-cycle costs are projected to be $5.3 billion, or $150 million per year. The WIPP site life-cycle costs cover a 35-year waste emplacement period followed by a 10-year decommissioning period. The total life-cycle cost of the Proposed Action is $19.1 billion or $10.1 billion when discounted. More details regarding life-cycle costs may be found in Appendix D.

Table 5-2
Life-Cycle Costs Under the Proposed Action
(in millions of 1994 dollars)[a]

Cost Information	Basic Inventory CH-TRU Waste	Basic Inventory RH-TRU Waste	Basic Inventory CH-TRU and RH-TRU Waste	Discounted Basic Inventory CH-TRU and RH-TRU Waste
Treatment Facilities	8,900	3,000	11,800	6,600
Transport by Truck	1,200	366	1,600	890
Disposal at WIPP	4,200	1,100	5,300	2,500
Excess RH-TRU Waste Storage	---	312	312	170
Total Life-Cycle Cost	14,300	4,500	19,100	10,100

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Totals may differ due to rounding.

DOE is restricted by the Consultation and Cooperation Agreement to disposal of a maximum of 7,080 cubic meters (250,000 cubic feet) of RH-TRU waste at WIPP. Thus, there is approximately 43,000 cubic meters (1,530,000 cubic feet) of RH-TRU waste under the Proposed Action that

could not be disposed of at WIPP and that would require long-term storage at the treatment facilities. Based on Draft WM PEIS storage cost estimates presented in the site data tables for Hanford and Oak Ridge National Laboratory (ORNL), the additional life-cycle cost of storing the remaining RH-TRU waste for 35 years would be approximately $312 million (in 1994 dollars) or $170 million when discounted. The need for this type of storage is not necessary under the action alternatives because the action alternatives assume that all TRU waste would be disposed of at WIPP.

5.1.7.2 Economic Impacts

TRU waste treatment activities would result in creation of additional direct, indirect, and induced jobs. Under the Proposed Action approximately 5,700 jobs would be created in the regions of influence (ROI) of the 10 major treatment sites (ANL-E, Hanford, INEL, LANL, LLNL, the Mound Plant [Mound], Nevada Test Site [NTS], ORNL, RFETS, Savannah River Site [SRS]).

Estimates of the impacts of the Proposed Action on employment, income, and the production of goods and services within the WIPP ROI are presented in Table 5-3. These regional impacts are estimated using an average project budget of $180 million per year over a 35-year waste disposal period. Over this period, the WIPP facility would remain a stable federal employer in the ROI economy, providing direct employment for 1,095 project personnel annually. Indirectly, the operation of WIPP (from 1998 through 2033) would annually support 2,300 additional jobs in the ROI work force. The estimates of total WIPP-induced employment within the ROI reflect the sum of these direct and indirect employment levels.

Because the projected annual budget is close to levels observed from 1988 to 1996, the Proposed Action is not expected to result in additional use of government-provided goods or services (schools, police, fire protection, and health protection) nor should it require major capital investments in public infrastructure within the ROI. For this same reason, the Proposed Action is

LIFE-CYCLE COSTS AND DISCOUNTING

A life-cycle is the entire life of a project from conceptual design to completion (through decommissioning). For these analyses, life-cycle costs at WIPP comprise waste management and disposal costs at the WIPP facility from the beginning of the disposal phase through decommissioning. At the treatment facilities, the life-cycle costs include all activities from conceptual design through closure. Total life-cycle costs also include transportation costs.

To allow for more consistent program evaluations relative to the various Draft WM PEIS estimates, the SEIS-II estimates are presented in 1994 dollars. Moreover, to allow for more consistent program evaluations relative to the various SEIS-II alternatives the life-cycle cost estimates are also presented in present value terms. The practice of discounting future costs gives more weight to money that is spent in the near future compared to money spent in the distant future. The justification for discounting future dollar values stems from the desire to know the equivalent, present-day values. For example, if $100,000 of expenses are anticipated during the 50th year of a project and the discount value is 5 percent per year, the equivalent present-day value would be $8,208.50, assuming that the $8,208.50 was reinvested continuously for 50 years with 5 percent compound interest. Thus, the process of discounting future dollar values reflects the common-sense understanding that money at the present time is worth more than money at a future time, as it takes only $8,208.50 today to produce $100,000 in 50 years.

The present value of the life-cycle costs are estimated using an annual discount rate of 4.1 percent, DOE's 1996 inflation-adjusted discount rate.

not expected to impact the local real estate market or result in major changes in the work force population. (Discussion of the economic impacts resulting from WIPP's closure is in the discussion of No Action Alternative 1.)

Table 5-3
Economic Impacts Within the WIPP ROI Under the Proposed Action

Economic Effects	Output of Goods and Services (in millions of 1994 dollars)	Employment (Full- and Part-Time Jobs)	Labor Income (in millions of 1994 dollars)
Direct - Annual	180	1,095	50
Indirect & Induced - Annual	330	2,300	70
Total - Annual	500	3,400	120
Total - Operations (35 years)	17,700	118,000 job-years	4,200
Total - Operations (Discounted)	9,600	N/A	2,200

5.1.8 Transportation

This section examines the potential environmental impacts of transporting TRU waste in accordance with the consolidation, treatment, and disposal methods described for the Proposed Action in Chapter 3. The results shown here update the results of SEIS-I. SEIS-II uses essentially the same methods for assessing transportation impacts as were used for SEIS-I. The major differences between the two sets of analyses are the following:

- SEIS-II analyses use 1990 Census data for population impacts. These data were not available for SEIS-I.
- SEIS-II analyses include transportation of TRU waste from several sites that are storing small quantities of the waste. Transportation of this waste was not considered in SEIS-I.
- SEIS-II analyses use a larger TRU waste inventory.
- SEIS-II analyses consider three transportation risk assessments prepared since SEIS-I was published. They are the *Comparative Study of WIPP Transportation Alternatives* (DOE 1994a) requested by Congress, the Draft WM PEIS (DOE 1995f), and the *Engineered Alternatives Cost/Benefit Study Final Report* (DOE 1995g).

In assessing the impacts of transporting TRU waste, several measures were used. The most fundamental of these was the number of traffic accidents, fatalities, and injuries likely to occur as a result of transportation unrelated to the waste type. Another impact assessed was that caused by vehicle emissions (diesel exhaust); this impact is termed pollution health effects. A third measure, termed accident-free radiological impacts, is associated with the external radiation present around a TRUPACT-II or RH-72B container as it is being shipped. The general public and transportation workers would be exposed to very low levels of radiation during shipment. The final measure is associated with accidents that are severe enough to breach the waste packages and release some of the radioactive and hazardous material being shipped.

UNCERTAINTIES IN TRANSPORTATION IMPACT ANALYSES

To account for inherent uncertainties in the data, conservative assumptions were made so that reported impacts would bound potential impacts. The following are descriptions of the sources of uncertainty.

Waste Inventory and Characterization

The physical form and radionuclide content of TRU waste were considered when estimating both the external dose rate during accident-free transport and the dose to exposed individuals from transportation accidents. Therefore, conservative assumptions were applied consistently to the waste data to limit potential differences between sites and across alternatives.

Route Determination

Although highway infrastructure and demographics may change considerably over the next 35 to 190 years, representative routes were established for all origin and destination sites in each of the alternatives. The routes were determined using current guidelines, regulations, and practices.

Radiation Doses

Based on the natural variability of key physical processes (i.e., atmospheric dispersion of radioactive material and cancer induction), conservative assumptions were made regarding radiation dose assessment for transportation activities. Parameter values were selected that would provide reasonable upper limits or, in some cases, bounding estimates of potential impacts. Because parameters and assumptions were applied consistently to all alternatives, the relative comparisons between alternatives would not be affected.

For TRU waste shipments, the largest contributors to the collective population dose were found to be, in decreasing order of importance: (1) accident-free dose to members of the public at stops; (2) accident-free dose to transportation crew members; (3) accident-free dose to members of the public sharing the route; (4) accident-free dose to members of the public living along the route; (5) accident dose risk to members of the public in an urban population zone (mean density of 3,861 persons per kilometer). Approximately 80 percent of the estimated public dose would be incurred at stops, 15 percent would be incurred by the members of the public sharing the route, and 5 percent would be incurred by members of the public living along the route. In general, the accident contribution to the total impact would be negligible as compared to the accident-free impact.

The first step in all of these analyses was to determine the highway routes that would be used for transporting waste to WIPP. All of the impacts are a function of route characteristics, the number of shipments via each route, and, for the accident risks, the accident environment associated with a particular mode of transportation and the behavior of the waste form and packaging in that accident environment. Therefore, a major focus of this section is to summarize important route characteristics, the waste shipment volumes using each route, and the impacts of potential accidents.

The following sections estimate the impacts of shipping TRU waste to WIPP. The first subsection is devoted to developing the data needed. It is followed by subsections devoted to analyzing the various transportation impacts associated with transporting waste from the treatment sites to WIPP. Each section also presents the impacts for transporting waste from sites with smaller quantities to the treatment sites. The results of the truck transportation analyses to WIPP were adjusted to account for the additional miles and shipments between these sites.

5.1.8.1 Route Characteristics and Shipment Projections

Under the Proposed Action, waste destined for WIPP would originate at 20 sites around the United States. Many of these sites have generated small quantities of TRU waste and are no longer generating waste. The waste present at these sites would be shipped to one of 10 sites with larger TRU waste volumes (see Chapter 3 for tables and maps detailing the consolidation). The number of CH-TRU and RH-TRU waste shipments from each of these 10 sites to WIPP under the Proposed Action are shown in Table 5-4. The number of TRU waste shipments is primarily dependent on limitations concerning weight, gas generation, plutonium-239 equivalent curies (PE-Ci), and thermal power limits that are incorporated into the planning-basis WAC. The methods used to determine the number of shipments are outlined in Appendix A.

Table 5-4
Number of Truck Shipments to WIPP Under the Proposed Action[a]

Waste Treatment Site	CH-TRU Waste	RH-TRU Waste
Argonne National Laboratory-East	28	0
Hanford Site	13,666	3,178
Idaho National Engineering Laboratory & Argonne National Laboratory-West	5,782	3,136
Lawrence Livermore National Laboratory	162	0
Los Alamos National Laboratory	5,009	367
Mound Plant	59	0
Nevada Test Site	86	0
Oak Ridge National Laboratory	251	1,276
Rocky Flats Environmental Technology Site	2,485	0
Savannah River Site	2,238	0
Total	**29,766**	**7,957**

[a] The number of shipments from sites with smaller quantities can be found in Appendix E. There would be 29 CH-TRU waste shipments and 337 RH-TRU waste shipments. Impacts from the transportation of TRU waste to the major treatment sites (see Appendix E) are small relative to impacts from shipment between the major treatment sites and WIPP.

The HIGHWAY code (Johnson et al. 1993) was used to estimate trip lengths from the 10 major treatment facilities to WIPP and to estimate the corresponding population density fractions along the routes. Built into the HIGHWAY code are the routes that were selected by the states and accepted by the Department of Transportation for the shipment of route-controlled quantities of radioactive materials. Although the majority of shipments to WIPP will not fall within the definition of a highway route-controlled quantity (HRCQ) (49 CFR Part 397.101(l)), DOE, as a matter of policy, has determined that all shipments, whether they are empty or full and whether or not they meet the definition, will use the "preferred highway" system required for shipments meeting the definition of HRCQ. Selected routes, shown in Appendix E, generally follow interstate highways. The major exception to this is New Mexico, where the state has selected U.S. Highway 285 as the primary northern route between Interstate-25 near Santa Fe, New Mexico, and WIPP, and the southern route between Interstate-20 at Pecos, Texas, and WIPP. Table 5-5 presents the total miles from the 10 major treatment sites to WIPP and the total miles along the route for rural, suburban, and urban population zones for shipments to WIPP under the Proposed Action.

Table 5-5
Mileage for Shipping TRU Waste by Truck to WIPP Under the Proposed Action[a]

Origination Site	Total One-Way Truck Mileage	Miles in Each Population Zone		
		Rural	Suburban	Urban
Argonne National Laboratory-East	1,696	1,412	259	25
Hanford Site	1,807	1,645	144	18
Idaho National Engineering Laboratory & Argonne National Laboratory-West	1,392	1,263	114	15
Lawrence Livermore National Laboratory	1,452	1,304	100	48
Los Alamos National Laboratory	341	318	21	2
Mound Plant	1,764	1,359	382	23
Nevada Test Site	1,194	1,118	63	13
Oak Ridge National Laboratory	1,439	1,160	265	14
Rocky Flats Environmental Technology Site	704	619	71	14
Savannah River Site	1,535	1,203	315	17

[a] The mileage from sites with small quantities of waste to the treatment sites can be found in Appendix E.

5.1.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation

Although the transportation of TRU waste cannot be made entirely impact free, reasonable planning and control strategies can usually reduce impacts to a level below that of comparable shipments (for example, commercial shipments of hazardous materials such as gasoline). WIPP would use such strategies to reduce impacts. A complete picture of the planning and control strategies are presented in Appendix C, Appendix L, and Appendix M of SEIS-I, and Appendix E of this document. Appendix C of SEIS-I summarizes emergency response training, procedures, and plans for the WIPP shipping campaign. Appendix L of SEIS-I summarizes the design, certification, and operation of the TRUPACT-II shipping container for CH-TRU waste and the NuPac 72B shipping cask for RH-TRU waste (the RH-72B is very similar in design to the NuPac 72B). Appendix M of SEIS-I (and Section 3.1.2.1 of this document) summarizes a trucking contract, including qualification standards and training requirements for drivers, and quality assurance standards applicable to operational activities. The qualifications and quality assurance standards are essentially unchanged since SEIS-I.

As outlined in the *Transuranic Materials Transportation Guide* (DOE 1996e), the trucking contractor is responsible for the routing of shipments in accordance with federal, state, Tribal, and local regulations. DOE, on behalf of the contractor, has coordinated these routes with the affected states. The DOE Carlsbad Area Office is responsible for providing a plan (DOE 1995a) for responding to emergencies involving TRU waste transportation. The plan has been completed and is available upon request. The level of response to an accident would be determined by the DOE Albuquerque Office, based on the type of accident as outlined in the Carlsbad Area Office emergency response plan. The levels are defined as 0 through III, with 0 representing the lowest severity (a minor accident), I representing potential penetration of TRU waste packaging, II representing definite penetration, and III representing a definite release or the need for repackaging.

Once the appropriate level of response has been established, a team would respond with the necessary equipment. The team would also coordinate with the carrier to expedite recovery of TRU waste and the packaging. Personnel would be on call 24 hours a day when shipments are en route.

For the SEIS-II analyses of accidents, injuries, and fatalities, truck accident statistics compiled for each state by highway type were used to determine route-specific accident, injury, and fatality rates (Saricks and Kvitek 1994). The route mileage through each state, obtained using HIGHWAY, was multiplied by the state traffic accident, injury, or fatality rates. The products were then summed for the route, and the sums were divided by the total route mileage. With the exception of the State of New Mexico, the accident rate data for federally aided interstate highways were used. For New Mexico, because much of the waste would travel on U.S. Highway 285, the rate for federally aided primary roads was used.

Once the route-specific accident, injury, and fatality rates per route were obtained, they were multiplied by the number of shipments along each route to obtain the estimated number of accidents, injuries, and fatalities. These impacts were estimated using round-trip mileage. They were then adjusted to account for the small number of shipments between the 10 sites with small amounts of waste and the 10 major treatment sites.

For the Proposed Action, 76 accidents, 48 injuries, and six traffic-related fatalities were estimated over the transportation period of 35 years. The results are shown in Table 5-6.

Table 5-6
Nonradiological Impacts of Transporting TRU Waste by Truck Under the Proposed Action[a]

Impact	CH-TRU Waste	RH-TRU Waste	Total Impact
Number of Accidents	58	18	76
Number of Traffic Injuries	37	11	48
Number of Traffic Fatalities	5	1	6
Pollution Health Effects (fatalities)	0.14	0.06	0.20

[a] All numbers include the impacts from transportation between sites with small volumes of waste and the 10 major treatment sites.

Similarly, the estimated pollution health effects due to diesel exhaust are shown in Table 5-6. These are potential cancer fatalities attributed to exposure to diesel exhaust. This health effect is based upon the total miles traveled in urban areas and a factor that estimates vehicle exhaust impacts on the public, 9.9×10^{-8} latent cancer fatalities (LCF) per kilometer (1.6×10^{-7} LCF per mile) (Rao et al. 1982). Urban areas have greater concentrations of vehicle exhaust. These areas sometimes have air quality concerns as well. Urban areas were assumed to have the largest mean population density (3,861 persons per square kilometer [10,000 persons per square mile]).

5.1.8.3 Accident-Free Radiological Impacts from Truck Transportation

Accident-free radiological impacts occur during the routine transportation of radioactive material and result from direct public and worker exposure to radiation at levels allowed by transportation regulations. While the TRUPACT-II and RH-72B packaging provides radiation shielding, workers, vehicle crew members, and the public along the transportation routes would be exposed to radiation at very low dose rates during transportation. The RADTRAN code (Neuhauser and Kanipe 1992) was used to estimate the impacts due to this radiation. The following categories of accident-free occupational and nonoccupational exposures were estimated (the nomenclature provided in RADTRAN is presented in parentheses):

- ***Along Route*** *(Off Link Exposure):* Exposure to individuals adjacent to routes of travel
- ***Sharing Route*** *(On Link Exposure):* Exposure to individuals sharing the right of way
- ***Stops*** *(Stops):* Exposure to individuals while shipments are at rest stops
- ***Occupational*** *(Occupational Exposure):* Exposure to waste transportation crews

The sum of the first three items in the above list equals the total nonoccupational exposure. The important RADTRAN input parameters related to TRU waste shipment characteristics are the transportation index (TI), which is the exposure rate at 1 meter (3.3 feet) from the container (in mrem per hour); the frequency of vehicle stops; the number of people exposed and their distances from the container; and the speed of the vehicle.

The TI for a TRUPACT-II or RH-72B shipment is a function of the radionuclide content of the waste being shipped. Typically, the radionuclide content of the waste is different for each generator site. For WIPP shipments, an average radionuclide inventory was developed for each site (see Appendix A). The TIs were then calculated. Because of the uncertainty of the TRU waste radionuclide inventory, a conservative TI of 4 (4 mrem per hour at 1 meter) was chosen for all CH-TRU waste shipments and a TI of 10 (10 mrem per hour at 1 meter) for all RH-TRU waste shipments. All of the calculated TIs were less than those used to estimate impacts (for details on the process used to calculate the TIs, see Appendix E).

The accident-free radiological impacts are presented in Table 5-7. These impacts were estimated using factors of 4×10^{-4} LCF per person-rem for occupational exposures and 5×10^{-4} LCF per person-rem for nonoccupational exposures (ICRP 1991). Table 5-7 also summarizes the impacts to those living along routes, those in vehicles sharing the routes, and those exposed during stops for both CH-TRU and RH-TRU waste shipments. The accident-free impacts for transporting TRU waste under the Proposed Action include the impacts associated with the consolidation of TRU waste from those sites with smaller quantities of waste. These impacts contribute approximately 1 percent to the total accident-free transportation impacts under the Proposed Action.

Table 5-7
Aggregate Accident-Free Population Radiological Impacts from Truck Transportation Under the Proposed Action (LCFs)[a]

Exposure Category	CH-TRU Waste	RH-TRU Waste	Total
Occupational	0.3	0.03	0.3
Nonoccupational			
Stops	2	0.8	2.8
Sharing Route	0.1	0.05	0.2
Along Route	0.04	0.02	0.06
Nonoccupational Total	2.1	0.9	3.0

[a] Exposure during stops is based upon 50 individuals exposed at 20 meters. Stop time, in hours, is based upon 0.011d where d is the distance traveled in kilometers. These parameters are built into the RADTRAN code but substantially overestimate exposures from WIPP shipments. Because WIPP shipments would use 2-driver teams (eliminating the need for overnight stops to sleep) and because the shipments would stop at sites chosen, in part, for their lack of population, the actual impacts from stops would be much lower.

ESTIMATING RADIOLOGICAL IMPACTS

Estimation of potential human health impacts involves a series of calculations that indicate the potential health consequence of a particular action or accident, and the probability that the action or accident would occur. Impacts can be calculated both for individuals and for a population. The probability of occurrence for routine actions is 1.0, meaning the action (e.g., chronic release from a permitted exhaust point) will occur at regular intervals, typically daily, over a year of operations. The probability of occurrence for accidents, therefore, is between zero and 1.0, indicating that the nonroutine event might be expected to occur at some random point in time over the entire operations period.

The health effect of concern from low levels of radiation exposure is a radiation-induced cancer fatality. To quantify the radiological impact, the radiation dose must be calculated. The dose is a function of the exposure pathway (external, inhalation, or ingestion) and the type and quantity of radionuclides involved. After the dose is estimated, the health impact is calculated from current internationally-recognized risk factors. For this document, potential radiological impacts are based on a scenario that includes prudently conservative release, exposure, and risk factor estimates. The impact estimates bound any that would be expected because of the use of conservative assumptions.

The unit of radiation dose for an individual is the rem. A millirem (mrem) is 1/1,000 of a rem. The unit of dose for a population is person-rem and is determined by summing the individual doses of an exposed population. Dividing the person-rem estimate by the number of people in the population would indicate the average dose to a single individual. The impacts from a small dose to a large number of people can be approximated by the use of population (i.e., collective) dose estimates.

To estimate the human health impact from radiation dose, a dose-to-risk factor that indicates the potential for a LCF is used. An LCF is a fatality resulting from a cancer that was originally induced by radiation, but which may occur years after the exposure. The dose-to-risk factor for low (less than 20 rem) annual doses is 0.0005 LCF per person-rem for the general public, which includes the very young and the very old, and 0.0004 for the worker population. For example, a population dose of 2,000 person-rem is estimated to result in one additional cancer fatality (0.0005 x 2,000 = 1) in the general public. The dose-to-risk factor for an individual is doubled if the individual dose is greater than 20 rem/year (20,000 mrem per year).

The average individual in the United States receives a dose of 0.3 rem (300 mrem) each year from background radiation. Background radiation sources include radon that has concentrated in homes from foundation soil sources, uranium found in rocks used as building materials, and cosmic radiation from the earth's atmosphere (NCRP 1987). The average lifetime chance or probability of cancer to a member of the public from a 70-year exposure due to background radiation is 0.01 (70 x 0.3 x 0.0005). That is, the best current radiation risk estimates are that one in 100 people will die from cancer due to background radiation.

Accident-free radiological impacts include the probability of incurring an LCF for maximally exposed individuals (MEI). The assumptions and scenarios used to determine the MEIs were as follows:

- *Individual stuck in traffic next to a truck transporting TRU waste.* For this assessment, it was assumed that the individual would have an exposure distance of 1 meter (3.3 feet) for an exposure time of 30 minutes. The individual was assumed to be exposed only once.

- *An inspector of trucks ready for departure.* For this assessment, it was assumed that the inspector would have an exposure distance of 1 meter (3.3 feet) for 30 minutes, that the inspector would work at the same job for 10 years, and that there would be three shifts working the same job. The number of shipments inspected would depend on the total number of shipments to be shipped from the site and the rate at which they would be

shipped. In actuality, in accordance with current DOE administrative requirements, such an inspector's dose would be limited through radiation monitoring, and the inspector would be rotated into a new job should his dose climb to the administrative limit. In order to be conservative, this administrative requirement was not taken into consideration for SEIS-II analyses.

- *A person who performs state vehicle safety inspections.* For this assessment, it was assumed that the individual would inspect 20 percent of the TRU waste shipments, that the inspector would work at the same job for 10 years, and that the average exposure distance would be approximately 1 meter (3.3 feet) for 1 hour. To bound the state inspector's dose, it was assumed that the individual would work on the route on which the majority of the waste enters New Mexico. Again, in actuality this person's dose would be limited by administrative rules and the inspector would be rotated into a new position. In order to be conservative, this was not taken into consideration for SEIS-II analyses.

- *Individual residing along a shipment route.* For this assessment, it was assumed that the individual would have an exposure distance of 30 meters (100 feet) over a 70-year period.

- *Individual who is a rest stop employee.* For this assessment, it was assumed that all trucks stop at the same location, that there are three shifts working at the truck stop, and that the individual works at the truck stop for 10 years. It was estimated that the individual would be exposed to 20 percent of all TRU waste shipments sent to WIPP over a 10-year period. The individual was assumed to be exposed over a 2-hour stop duration at a distance of 20 meters (66 feet).

Table 5-8 summarizes the maximum probability of incurring an LCF for these individuals. The departure and state inspectors would have the highest probability of health effects due to the performance of their responsibilities associated with TRU waste shipments.

UNDERSTANDING SCIENTIFIC AND EXPONENTIAL NOTATION

Scientific notation is used in this document to express numbers that are so large or so small that they can be difficult to read or write. Scientific notation is based on the use of positive and negative powers (or exponents) of 10. A number written in scientific notation is expressed as the product of a number between 1 and 10 and a positive or negative power of 10. Examples include the following:

Positive Powers of 10	**Negative Powers of 10**
$10^1 = 10 \times 1 = 10$	$10^{-1} = 1/10 = 0.1$
$10^2 = 10 \times 10 = 100$	$10^{-2} = 1/100 = 0.01$
and so on, therefore,	and so on, therefore,
$10^6 = 1{,}000{,}000$ (or 1 million)	$10^{-6} = 0.000001$ (or 1 in 1 million)

A power of 10 is also commonly expressed as "E", where "E" means "x 10". For example, 3×10^5 can also be written as 3E+5, and 3×10^{-5} is equivalent to 3E-5. Therefore, 3E+5=300,000 and 3E-5 = 0.00003. This is called exponential notation.

The data tables in this section use exponential notation for numbers that are either very large or very small. The text uses scientific notation to convey these numbers.

Probability is expressed as a number between 0 and 1 (0 to 100 percent likelihood of the occurrence of an event). The notation 3E-6 can be read 0.000003, which means that there are three chances in 1,000,000 that the associated result (e.g., fatal cancer) will occur in the period covered by the analysis.

Table 5-8
Lifetime Accident-Free Radiological Impacts to MEIs from Truck Transportation Under the Proposed Action (Probability of an LCF)

MEI	CH-TRU Waste	RH-TRU Waste	Total
Stuck in traffic next to TRU waste shipment	2.5E-6	5.0E-6	7.5E-6
Departure Inspector	1.1E-3	1.1E-3	2.2E-3
State Vehicle Inspector	9.6E-4	5.2E-4	1.5E-3
Residing adjacent to access route	2.5E-4	1.5E-4	4.0E-4
Rest stop employee	1.5E-3	1.8E-3	3.3E-3

5.1.8.4 Radiological Impacts from Truck Transportation Accidents

As part of the U.S. Nuclear Regulatory Commission (NRC) package certification process, computer simulations are used to model the behavior of packaging in a series of tests that are internationally recognized to represent a severe accident. These simulations are followed by physical tests. By comparing the results of the physical tests with the simulation results, it is possible to conclude, with a high degree of confidence, that a properly constructed and maintained package will not be breached in all but a small number of accidents in which forces imposed on the packaging are much more severe than the tests. This section looks at the impacts associated with the small fraction of severe accidents that would cause the release of radioactive material.

Two types of analyses were conducted for SEIS-II radiological impacts from accidents. For the first type of analysis, the RADTRAN code was used to estimate the radiological impact from accidents during transport from each of the 10 major treatment sites to WIPP. For this analysis, a conservative radionuclide inventory was used; it was assumed every TRU waste package would be filled with waste containing the highest level of radionuclides and hazardous material allowable by the planning-basis WAC. The first type of analysis took into account eight different severity categories of accidents, their probabilities of occurrence, the distance from each site, and the number of shipments. The total accident risk from each of the 10 sites was obtained by summing the risks calculated for the severity categories. A complete discussion of these analyses is included in Appendix E.

FRACTIONAL LCFs

Sometimes, calculations of the number of latent cancer fatalities associated with radiation exposure do not yield whole numbers, and, especially in environmental applications, may yield numbers less than 1.0. For example, if each member of a population of 100,000 were exposed to a total dose of 0.001 rem, the collective dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 (100,000 persons x 0.001 rem x 0.0005 latent cancer fatalities/person-rem = 0.05 latent fatal cancers).

How should one interpret a nonintegral number of latent cancer fatalities, such as 0.05? The answer is to interpret the result as a statistical estimate. That is, 0.05 is the *average* number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people. For most groups, individuals would not incur a latent cancer fatality from the 0.001 rem dose each member would have received. In a small fraction of the groups, 1 latent fatal cancer would result; in exceptionally few groups, 2 or more latent fatal cancers would occur. The *average* number of deaths overall of the groups would be 0.05 latent fatal cancers (just as the average of 0, 0, 0, and 1 is ¼, or 0.25). The most likely outcome is 0 latent cancer fatalities.

Assumptions for these analyses included the following:

- Release fractions increase with the severity category.
- Because the TRUPACT-II and RH-72B must endure severity category I and II accidents without a breach, no release was calculated for these two severity categories.
- Only one of the TRUPACT-IIs in a shipment would be breached in an accident of any of the severity categories. This assumption is based on studies that indicate hard targets along roadways are too few or are of the wrong orientation to cause the breach of more than one TRUPACT-II (see Appendix E).
- Only one RH-72B is transported per truck. That one cask would be breached.
- The population densities used to estimate impacts were six persons per square kilometer (16 per square mile) for rural areas, 719 persons per square kilometer (1,863 per square mile) for suburban areas, and 3,861 persons per square kilometer (10,000 per square mile) for urban areas.
- The analyses assumed that stable atmospheric conditions predominated, maximizing impacts.
- Impacts were calculated using a resuspension particle half-life of 365 days.

The results for the first type of accident analysis, route-specific accidents summed over the entire shipping campaign, are presented in Table 5-9.

Table 5-9
Aggregate Radiological Impacts from Potential Truck Transportation Accidents Under the Proposed Action (LCFs)[a]

Waste Origin	CH-TRU Waste	RH-TRU Waste	Total
Argonne National Laboratory-East	5.0E-4	---	5.0E-4
Hanford Site	0.3	4.0E-3	0.3
Idaho National Engineering Laboratory & Argonne National Laboratory-West	0.08	2.6E-3	0.08
Lawrence Livermore National Laboratory	1.5E-3	---	1.5E-3
Los Alamos National Laboratory	3.5E-3	1.5E-5	3.5E-3
Mound Plant	1.0E-3	---	1.0E-3
Nevada Test Site	5.0E-4	---	5.0E-4
Oak Ridge National Laboratory	3.0E-3	1.0E-3	4.0E-3
Rocky Flats Environmental Technology Site	8.0E-3	---	8.0E-3
Savannah River Site	0.02	---	0.02
Total	**0.42**	**7.6E-3**	**0.43**

[a] Includes both probability of the accident and consequences.

A 1987 NRC study estimated that only 0.6 percent of truck and rail accidents involving Type B containers or casks could cause a radiation hazard to the public (Fischer et al. 1987). There are 76 potential accidents under the Proposed Action, and only half of these accidents are expected to occur when the canister or cask is loaded. Therefore, of the approximately 38 potential transportation accidents estimated to occur under the Proposed Action when the canister or cask is

loaded, none would be expected to result in package failure. Still, the second type of analysis was an assessment of four bounding accidents: two assumed a breach of a TRUPACT-II and two assumed a breach of an RH-72B cask. The accidents were assumed to occur under conditions that would maximize, within reasonable bounds, the impacts to exposed population groups. Assumptions for these analyses included the following (see Appendix E for details):

- During the accidents, one TRUPACT-II or RH-72B cask would be breached.

- Each accident would occur in an urban area with a population density of 3,861 persons per kilometer (10,000 persons per square mile), under stable atmospheric conditions that would maximize exposure to nearby populations.

- Two types of inventories were considered for the four accidents: a conservative inventory similar to that used for the first type of analysis above and an inventory based on the average concentrations of radionuclides and hazardous chemicals at Hanford (for RH-TRU waste) and SRS (for CH-TRU waste). The conservative inventory was determined by maximizing the concentrations of radionuclides and hazardous chemicals to the limits allowed by the planning-basis WAC.

- Breach of the TRU waste packaging would result in 0.02 percent of the radioactive material being released to the environment in a respirable form (DOE 1990).

- Impacts were calculated using a resuspension particle half-life of 365 days.

The results for the second type of accident analysis were the following:

- For the accident with the conservative inventory in a breached TRUPACT-II, the estimated dose would result in 16 LCFs in the exposed population. The estimated maximum individual dose would result in a 6 percent chance of an LCF. The estimated population doses were dominated by inhalation contributions (initial or from resuspension).

- For the accident with a conservative inventory in a breached RH-72B, the estimated dose would result in 16 LCFs in the exposed population. The estimated maximum individual dose would result in a 6 percent chance of an LCF.

ESTIMATING ACCIDENT RISK

Assessing the radiological or hazardous chemical impact due to accidents is typically done by estimating the probability that such an accident might occur and, for a selection of accidents, by estimating the accident's consequences. The probability, or chance, that the accident will occur, and the consequences of the accident are multiplied together to determine the total risk of the accident.

Accident probability is usually determined by historical information on accidents of a similar type or severity. Determining accident consequences requires estimation of the quantity of radionuclides or hazardous chemicals likely to be released, the exposure pathways that will bring the radionuclides or hazardous chemicals into contact with people, and the environmental transport mechanisms. Because of the many variables in these calculations, conservative or bounding assumptions are commonly used and risks tend to be overestimated.

- For the accident with average concentrations of radionuclides and hazardous chemicals in a breached TRUPACT-II, the dose estimated would result in 3 LCFs in the exposed population. The estimated maximum individual dose would result in a 4 percent chance of an LCF.

- For the accident with average concentrations of radionuclides and hazardous chemicals in a breached RH-72B, the total population dose estimated would result in a 0.04 LCF in the exposed population. The estimated maximum individual dose would result in a 0.07 percent chance of an LCF.

5.1.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents

This section estimates the impacts associated with exposure to hazardous constituents (as defined by the Resource Conservation and Recovery Act [RCRA]) during the transportation of TRU mixed waste to WIPP. Hazardous chemicals in TRU waste include VOCs and certain metals listed as hazardous chemicals in RCRA. During routine transportation of TRU mixed waste, exposures to hazardous chemicals would not occur because the TRUPACT-II and RH-72B packagings are not vented, and the hazardous chemical components in the waste are completely contained. No impacts to human health would be posed by the hazardous constituents under routine transportation conditions. Impacts due to accidents, however, are possible. It is those impacts that are evaluated in this section.

Hazardous chemical inventories were developed as described in Appendix A. For those VOCs where maximum allowable levels are stipulated in the planning-basis WAC, those levels were assumed to be in the shipping container being transported during an accident. Where no maximum level was specified in the planning-basis WAC, the highest level found during waste drum sampling was selected to ensure that the typical concentration is bounded. For hazardous metals, the concentration was assumed to be the average of those found during waste drum sampling (see Section A.5).

It was assumed that CH-TRU waste hazardous chemical accident scenarios would bound any impacts from RH-TRU waste shipments; therefore, no hazardous chemical accidents were analyzed for RH-TRU shipments. The bases for this assumption included the relative shipment capacity (hazardous chemical inventory) of 14 CH-TRU waste drums or 2.91 cubic meters (103 cubic feet) of waste compared to the capacity of an RH-72B cask or 0.89 cubic meters (32 cubic feet) of waste. A TRUPACT-II, therefore, is likely to hold nearly three times the hazardous chemicals that an RH-72B would hold. For the purpose of analysis, it was assumed that the RH-TRU waste hazardous chemical inventory is the same as the CH-TRU hazardous chemical inventory.

The approach used to assess human health effects from hazardous chemical exposures during transportation accidents was similar to that used for SEIS-I. The assessment criteria used were the immediately dangerous to life or health (IDLH) values provided by the National Institute of Occupational Safety and Health (NIOSH). Each chemical was considered separately; the impacts from each chemical are not necessarily additive. As long as the ratio of possible intake to IDLH value was less than 1, the risk of health impact was considered zero, and there was no need to further evaluate an exposure. The hazardous constituents that were analyzed are presented in Table 5-10.

ESTIMATING HAZARDOUS CHEMICAL IMPACTS

Hazardous chemical exposures can pose two types of health effects, carcinogenic (causing cancer) and noncarcinogenic (for example, respiratory problems or skin irritation). Some hazardous chemicals can potentially produce both carcinogenic and noncarcinogenic health effects. Health effect analyses require knowledge of the exposure pathway and intake (typically by inhalation, but also by ingestion), and use of health effect risk factors that allow estimated intakes to be converted to estimates of health effects.

Carcinogenic Risk

Carcinogenic risk is probabilistic; that is, every intake carries with it some probability of cancer incidence regardless of how small the intake is. The risk varies linearly with exposure, and there is assumed to be no threshold below which an effect would not occur. The U.S. Environmental Protection Agency (EPA) has published carcinogenic risk factors to be used for estimating potential impacts from chronic (long-term) exposure to hazardous chemicals. The "slope factor" of a hazardous chemical is used to convert chronic hazardous chemical intakes to the probability of cancer incidence. The chronic exposure is assumed to last for a 70-year lifetime. Slope factors are specified as the risk per average daily intake over that 70-year period.

No standard method exists to calculate the carcinogenic risk from an acute (one-time or short-term) intake. The method selected for SEIS-II analyses used the chronic-exposure slope factors and assumed the total acute intake was averaged over the 70-year lifetime. In practice then, slope factors were used but specified as the risk per total acute intake.

Noncarcinogenic Health Effects

In contrast to carcinogenic health effects, noncarcinogenic health effects are deterministic, not probabilistic; that is, these effects are assumed to have an exposure threshold, and unless that threshold is reached no health effect would occur. EPA "reference doses" were used to estimate the potential noncarcinogenic health effects from chronic exposure to hazardous chemicals. Reference doses are specified as the chronic daily intake that would be required for the health effect to occur.

As was the case for acute exposures to carcinogenic hazardous chemicals, no standard method exists for estimating the noncarcinogenic health effects from acute exposures to hazardous chemicals. The method selected for SEIS-II analyses used the NIOSH IDLH values, or calculated IDLH-equivalent intakes. IDLH values are the air concentrations that would result in serious or life-threatening health effects if an individual were to be exposed at that concentration for 30 minutes. IDLH-equivalent intakes were calculated using the IDLH parameters to estimate potential impacts from exposure times less than 30 minutes. The IDLHs are air concentrations with units of milligrams per cubic meter (mg/cubic meter) or parts per million (ppm) of the hazardous chemical in air. IDLH-equivalent values are in mass quantities of intake, such as milligrams (mg).

Hazardous chemical impacts were evaluated for a bounding, severity category VIII accident. The accident would breach one of the three TRUPACT-IIs. The entire TRUPACT-II inventory of VOCs was assumed to be released (release fraction = 1.0), and hazardous metals would be released as particulates with a release fraction of 2×10^{-4} (DOE 1990). The receptor was assumed to be a public MEI located 1,000 meters (3,300 feet) downwind from the accident, exposed at the centerline of the released plume of chemicals for two hours under stable meteorological conditions and low wind speed. Table 5-10 presents the hazardous chemicals analyzed and impacts to the MEI as a fraction of the chemical-specific IDLH value. For all chemicals analyzed, the concentration to which the MEI would be exposed would be no more than about 1/10,000th (1.1×10^{-4} for 1,2-dichloroethane) of the chemical's IDLH value. Therefore, no human health effects would be expected from acute exposure to hazardous chemicals released from a severe transportation accident.

Table 5-10
Hazardous Chemical Impacts for a Severe Truck Transportation Accident Under the Proposed Action[a]

Chemical	IDLH (parts per million)	IDLH (milligrams per cubic meter)	Receptor Concentration (milligrams per cubic meter)	Receptor Concentration/IDLH Value
Carbon Tetrachloride	200	1,278	0.03	2.3E-5
Chloroform	500	2,480	0.02	7.7E-6
Methylene Chloride	2,300	8,119	0.8	9.7E-5
1,1,2,2-Tetrachloroethane	100	700	0.02	2.6E-5
Chlorobenzene	1,000	4,680	0.01	2.6E-6
Methyl Ethyl Ketone	3,000	9,000	0.07	7.9E-6
Toluene	500	1,915	0.02	8.5E-6
1,2-Dichloroethane	50	206	0.02	1.1E-4
Beryllium	---	4	1.5E-5	3.7E-6
Cadmium	---	9	2.1E-7	2.4E-8
Lead	---	100	5.9E-4	5.9E-6
Mercury	---	10	2.5E-4	2.5E-5

[a] Assumes a severity category VIII accident of a CH-TRU waste shipment.

5.1.9 Human Health Impacts from Waste Treatment and Disposal Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment and waste disposal operations under the Proposed Action. Throughout this section, the potential impacts from treating waste to planning-basis WAC and from the disposal operations at WIPP are reported separately.

Impacts from waste treatment under the Proposed Action were adjusted from those presented in the Draft WM PEIS (DOE 1995f); a description of this adjustment is provided in Appendix B. Treatment of the waste may result in the release of radioactive materials or hazardous chemicals, impacting the public and workers who would not directly handle waste (noninvolved workers).

Radiological Impacts Other Than LCFs

For SEIS-II, the impact reported from a radiation dose is the number of LCFs that may occur in a population, and the percent chance (or probability) of an LCF occurring in a maximally exposed individual. Other radiological impacts could result, such as a nonfatal cancer or severe hereditary effect. The risk of an LCF, however, is the dominant risk.

For the general public, consideration of nonfatal cancers would increase the impact estimate by 20 percent and, for severe hereditary effects, the impact estimate would increase by another 20 percent. For workers, consideration of nonfatal cancers would increase the impact estimate by 20 percent and for severe hereditary effects, by an additional 26 percent (ICRP 1991).

Direct radiation from the waste would present potential radiological impacts for workers who would handle waste (involved workers) at the treatment sites. The public MEI impact is presented for the site with the highest estimated impact of all sites evaluated in the Draft WM PEIS. Population impact estimates from waste treatment are the sum of all population impact estimates for all treatment sites.

Potential impacts from WIPP waste handling and emplacement operations were calculated for the public living near WIPP, for WIPP noninvolved workers, and for WIPP involved workers. Potential impacts from routine releases of VOCs and radioactive gases were calculated because each waste drum or waste box would be vented to reduce gas buildup. Both workers and the public may be exposed to these releases. No release of particulate hazardous chemicals during routine operations would occur at WIPP because the vents on the drums have filters, and the drums would not be opened. For the involved workers, potential impacts also were calculated for exposure to direct radiation from waste container contents. Direct radiation impacts for others at WIPP were not calculated because of the distances between where the drums would be unloaded and emplaced and other work areas. The impacts from the disposal operations were calculated for releases occurring after waste is unloaded from the TRUPACT-II or RH-72B. The detailed methods and assumptions used to calculate the potential impacts are described in Appendix F.

The types and concentrations of VOCs in the TRU mixed waste were estimated from past sampling of CH-TRU waste containers (see Appendix A). Emissions from CH-TRU and RH-TRU waste containers were assumed to have similar concentrations of VOCs. Although an estimated 60 percent of the TRU waste is mixed waste, all TRU waste was considered TRU mixed waste for human health analyses. Weighted average headspace concentrations (concentrations in the void area of a drum) were estimated for waste at each treatment site and were used to estimate impacts from waste emplaced underground at WIPP. More conservative estimates of VOC emissions were used to estimate impacts to workers in the Waste Handling Building. The limited number of drums (or drum-equivalents if the waste is in other containers) that could be present in the Waste Handling Building were assumed to release quantities of VOCs based on weighted maximum headspace concentrations; this assumption was made to bound the potential impacts to a worker in this facility.

Radiological impacts are presented as the estimated number of LCFs in a population, and, for individuals, as the percent chance (or probability) of an LCF. As with the transportation analyses, the International Commission on Radiological Protection (ICRP) Publication 60 (ICRP 1991) dose-to-risk factors of 5×10^{-4} LCF per person-rem for the general public and 4×10^{-4} LCF per person-rem for the worker population were used to convert radiation dose to LCFs.

Impacts resulting from chronic exposure to hazardous chemicals may be either carcinogenic or noncarcinogenic. Carcinogenic impacts are presented as the estimated cancer incidence (number of cancers occurring) in a population and, for MEIs, as the percent chance (or probability) of a cancer occurring. EPA's slope factors were used to estimate cancer incidence from chronic exposure to hazardous chemicals. Noncarcinogenic health effects were evaluated using a hazard index (HI), which is the ratio of the estimated annual intake of a specific chemical divided by the EPA reference dose for that chemical (see the "Estimating Hazardous Chemical Impacts" textbox). An HI greater than 1 would predict the occurrence of the chemical-specific noncarcinogenic health effect. Estimates of the HI for involved workers for some prospective cases (such as WIPP waste handling) were done very conservatively, and resulted in an HI greater than 1. In these cases additional evaluations were made.

The air concentration to which the worker would be exposed was conservatively calculated and compared to the Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limit (PEL) values. The PELs are, typically, time-weighted averages that must not be exceeded during any 8-hour work shift or a 40-hour work week. A few hazardous chemicals that may be present in waste accepted at WIPP have PEL values that must not be exceeded over any time period; they are chloroform, methylene chloride, and beryllium. If the air concentration of the hazardous chemical of concern did not exceed the PEL, no worker noncarcinogenic health effects would occur for the scenario evaluated. Evaluation of the potential for noncarcinogenic health effects in waste treatment workers may be expressed as an exposure index, rather than an HI. This methodology was used in the Draft WM PEIS and is based on the ratio of the exposure level divided by an occupational exposure limit, rather than by the reference dose.

5.1.9.1 Public

Impacts to public populations and to the MEIs under the Proposed Action are presented in this section; results are presented in Table 5-11. Impacts from waste treatment and from WIPP disposal operations are presented separately because different populations and individuals would be impacted by these activities. Waste treatment would take place at multiple DOE sites that would not include WIPP, while disposal operations would take place only at WIPP. Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of each treatment facility, and WIPP. The MEI from waste treatment is presented for the highest individual waste treatment site, while the MEI from disposal operations would be near the WIPP site. See Chapter 3 for information on where treatment would occur under the Proposed Action.

Table 5-11
Lifetime Human Health Impacts to the Public
from Waste Treatment and WIPP Disposal Operations Under the Proposed Action

	Waste Treatment Impacts[a]		WIPP Disposal Operations Impacts	
Category	Radiological (LCF)[b]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)
MEI[c, d]				
CH-TRU Waste	9E-9 (L)	4E-12	3E-7	3E-8
RH-TRU Waste	9E-11 (S)	8E-12 (O)	3E-10	1E-9
Total Waste	9E-9 (L)	8E-12 (O)	3E-7	3E-8
Population[c]				
CH-TRU Waste	2E-4	2E-7	3E-4	2E-5
RH-TRU Waste	5E-6	2E-7	4E-7	9E-7
Total Waste	2E-4	4E-7	3E-4	2E-5

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring in the MEI, and number of LCFs occurring in the exposed population.
[c] The MEI and populations evaluated for treatment impacts and WIPP disposal operations impacts are different.
[d] L = LANL, O = ORNL, S = SRS

Waste Treatment

No radiation-related LCFs would be expected in the total population around the waste treatment sites (2×10^{-4} LCFs); no cancer incidence (4×10^{-7} cancers) would be expected in the total population from hazardous chemical exposure. The MEIs with the greatest impact would be at LANL for radiological impacts (9×10^{-7} percent chance of an LCF) and at ORNL for hazardous

chemical impacts (8 x 10^{-10} percent chance of a cancer incidence). No noncarcinogenic health effects are predicted; the maximum HI for the MEI would be 3 x 10^{-10}, and no health effect is predicted unless the HI is 1 or higher.

WIPP Disposal Operations

No LCFs would be expected in the population around WIPP from radiation exposure (3 x 10^{-4} LCFs). VOC releases were estimated by assuming that a single panel, fully emplaced with RH-TRU and CH-TRU waste (4.5 percent and 95.5 percent of panel waste volume, respectively) would release VOCs continuously throughout all 35 years of WIPP disposal operations. Because each panel would be gradually filled (over about 3 years) and then closed, reducing VOC releases, the assumption of a full panel continuously releasing VOCs is conservative. Still, no cancer incidence (2 x 10^{-5} cancers) would be expected in the population from hazardous chemical exposure.

The MEI was assumed to be located at the Land Withdrawal Area boundary, the closest point at which an individual could reside. The MEI would have a 3 x 10^{-5} percent chance of an LCF from radiation exposure, and a 3 x 10^{-6} percent chance of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur. The maximum HI for the MEI would be 7 x 10^{-5}, and no health effect is predicted unless the HI is 1 or higher.

5.1.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under the Proposed Action are presented in this section; results are presented in Table 5-12. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, handling or disposal of waste. Impacts from waste treatment and from WIPP disposal operations are presented separately because different noninvolved worker populations and individuals would be impacted by these activities. Waste treatment would take place at multiple DOE sites that would not include WIPP, while disposal operations would take place only at WIPP. Noninvolved worker population impacts were estimated for the total of all treatment sites, and for

Table 5-12
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment and WIPP Disposal Operations Under the Proposed Action

	Waste Treatment Impacts[a]		WIPP Disposal Operations Impacts	
Category	Radiological (LCF)[b]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)
Maximally Exposed Noninvolved Worker[c]				
CH-TRU Waste	7E-9 (S)	1E-11	4E-7	1E-7
RH-TRU Waste	3E-10 (H)	5E-11 (O)	7E-10	5E-9
Total Waste	7E-9 (S)	5E-11 (O)	4E-7	1E-7
Population[c]				
CH-TRU Waste	2E-5	5E-8	4E-4	1E-4
RH-TRU Waste	2E-7	5E-8	7E-10	5E-6
Total Waste	2E-5	1E-7	4E-4	1E-4

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring in the maximally exposed noninvolved worker, and the number of LCFs in the population.
[c] The individuals and populations evaluated for treatment impacts and operations impacts are different.
[d] H = Hanford, O = ORNL, S = SRS

WIPP. The impact to the maximally exposed noninvolved worker from waste treatment is presented for the highest individual waste treatment site, while the maximally exposed noninvolved worker from disposal operations was assumed to work continuously at the WIPP location where emissions have the least atmospheric dispersion and thus the greatest potential impact. This location was assumed to be 200 meters (660 feet) east of the exhaust filter building. The maximum ground-level concentrations of any airborne contamination would be expected at this location.

Waste Treatment

No LCFs would be expected in the total noninvolved worker population at the waste treatment sites (2×10^{-5} LCFs); no cancer incidence (1×10^{-7} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at SRS for radiological impacts (7×10^{-7} percent chance of an LCF) and at ORNL for hazardous chemical impacts (5×10^{-9} percent chance of a cancer incidence). No noncarcinogenic health effects would occur. The maximum HI for the maximally exposed noninvolved worker was found to be 3×10^{-9}, and no health effect is predicted unless the HI is 1 or higher.

WIPP Disposal Operations

No LCFs would be expected in the WIPP noninvolved worker population from radiation exposure (4×10^{-4} LCFs). VOC release estimates were the same as for the public. No cancer incidence (1×10^{-4} cancers) would be expected in the noninvolved worker population from hazardous chemical exposure. All 1,095 WIPP employees were assumed to be exposed at the same level as the maximally exposed noninvolved worker.

The maximally exposed noninvolved worker would have a 4×10^{-5} percent chance of an LCF from radiation exposure and a 1×10^{-5} percent chance of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur. The maximum HI for the maximally exposed noninvolved worker was found to be 6×10^{-4}, and no health effect is predicted unless the HI is 1 or higher.

Appendix F provides additional information on the methods used to determine impacts to noninvolved workers from WIPP disposal.

5.1.9.3 Involved Workers

Impacts to the involved worker populations under the Proposed Action are presented in this section; results are presented in Table 5-13. Involved workers are those directly involved in day-to-day waste treatment, disposal, and management activities. At the waste treatment facilities, such workers would include those who are in direct contact with waste during treatment or packaging to meet planning-basis WAC. At WIPP, they would include workers in the Waste Handling Building and those who would emplace waste underground. All worker exposures to radiation and hazardous chemicals would be controlled to as low as reasonably achievable (ALARA) levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-13
Lifetime Human Health Impacts to Involved Workers from Waste Treatment and WIPP Disposal Operations Under the Proposed Action

Category	Waste Treatment Impacts[a]		WIPP Disposal Operations Impacts	
	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)
Population[b]				(36 workers)
CH-TRU Waste	1.7	3E-5	0.3	9E-3
RH-TRU Waste	0.01	8E-6	≤0.3	5E-4
Total Waste	1.7	4E-5	≤0.6	0.01

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The involved worker populations evaluated for treatment impacts and WIPP disposal operations impacts are different.

Waste Treatment

Up to 1.7 radiation-related LCFs could occur in the worker population while no cancer incidence (4×10^{-5} cancers) would be expected from hazardous chemical exposure. No noncarcinogenic health impacts would occur. The maximum exposure index for a waste treatment worker would be 2×10^{-4}. Impacts from waste treatment under the Proposed Action were adjusted from those presented in the Draft WM PEIS (DOE 1995f); a description of this adjustment is provided in Appendix B.

WIPP Disposal Operations

Radiological impacts to the involved worker population at WIPP from disposal operations would be less than 0.6 LCFs, and hazardous chemical impacts would be less than 0.01 cancers. No noncarcinogenic health effects would occur. External radiation doses would be the primary source of potential radiological impacts to involved workers; there would be negligible impact from intakes of radioactive material. Worker population impacts were estimated using a total of 36 involved workers (32 Waste Handling Building workers and four underground workers).

The drum vent filters prevent the release of particulates, although small quantities of radioactive gases would be released from containers. Workers would be exposed to external radiation from radioactive decay of radionuclides in the waste and receive an external dose. Worker doses are administratively limited at WIPP to 1 rem per year for the whole-body and 50 rem per year for any extremity (DOE 1995h). CH-TRU waste containers are limited to external dose rates of 200 mrem per hour at the surface of the container. The majority of routine worker doses would result from the disposal of CH-TRU waste rather than RH-TRU waste because of the greater throughput volume and the use of remote disposal operations. Estimates of worker whole-body doses were made assuming that the worker would be exposed at 1 meter (3.3 feet) from the CH-TRU waste for 2 hours every workday.

WIPP involved worker radiological impact estimates were made assuming each involved worker who handled CH-TRU waste would receive a radiation dose (total effective dose equivalent [TEDE]) of 1 rem per year. Impacts to involved workers from RH-TRU waste handling were assumed to be the same or less than those from CH-TRU waste handling. This assumption is conservative because RH-TRU waste is typically handled using remote-handling equipment, workers are usually protected by radiation shielding, and stricter administrative procedures are used. The impact from handling RH-TRU waste, therefore, would be less than the impact from

handling CH-TRU waste. Each worker was assumed to be exposed over an effective 20-year period (2 years to fill each of 10 panel-equivalents).

Workers may routinely be exposed to VOCs released from the waste containers. Worker impacts are related to the quantity of VOCs released and the ventilation rate of the area where they work. Involved workers in the Waste Handling Building were assumed to be exposed to VOC emissions from the maximum number of drums or drum-equivalents that could be stationed in the Waste Handling Building at any one time (42 CH-TRU waste drums and 3 RH-TRU waste drum equivalents). All of the drums were assumed to continuously contain concentrations of VOCs equal to the weighted maximum headspace concentrations. A low ventilation rate was assumed for the Waste Handling Building.

An involved worker underground at WIPP was assumed to be exposed to the VOCs released from a nearby panel filled with CH-TRU and RH-TRU waste containers. A low ventilation rate was assumed for the underground area. Underground workers would normally be upwind of the ventilation air that passes over the waste containers. The potential carcinogenic impacts would be greater for the individual underground worker than for a Waste Handling Building worker, but no cancer incidence would be expected (0.01 cancers). Workers were assumed to be exposed for 35 years.

Noncarcinogenic health effects also were estimated for WIPP workers who would handle waste. The initial maximum HI estimates were 2 for the Waste Handling Building worker and 6 for the underground worker, so further evaluation was conducted for those constituents that had an HI near or greater than 1: (1) carbon tetrachloride for the Waste Handling Building (HI of 2) and the underground (HI of 6); and (2) methylene chloride for the Waste Handling Building (HI of 0.9). The air concentrations to which workers would be exposed were calculated and then compared with the PELs. For the VOCs noted above, the air concentrations would be at least three orders of magnitude below the PELs, well within permissible exposure limits, so no noncarcinogenic health effects would be expected.

5.1.9.4 Storage of Excess RH-TRU Waste

Under the Proposed Action only, a portion of the RH-TRU waste at Hanford and ORNL would not be disposed of at WIPP. The impacts of surface storage of 39,000 cubic meters (1.4 million cubic feet) of RH-TRU waste at Hanford and 4,000 cubic meters (41,000 cubic feet) of RH-TRU waste at ORNL were evaluated. The waste was assumed to be stored in RH-TRU waste canisters packaged to meet the planning-basis WAC. Radiological impacts would result from the release of gaseous radionuclides from the waste containers. The only gaseous radionuclide identified was carbon-14 (C-14) in RH-TRU waste at ORNL. Impacts from container VOC releases were estimated using the average weighted headspace concentration from waste packaged to the planning-basis WAC.

Impacts from long-term storage of the RH-TRU waste are shown in Table 5-14. Impacts to involved workers would be less than those shown for RH-TRU waste treatment in Table 5-13. Exposure of involved workers to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-14
Impacts from Storage of Excess RH-TRU Waste Under the Proposed Action

Impact Area	Radiological	Hazardous Chemical	
	LCFs[a]	Cancer incidence	Maximum HI
Public[b]			
Population	2E-5	3E-4	----
MEI	1E-9 (O)	4E-8 (O)	1E-5 (O)
Noninvolved Worker			
Population	4E-5	6E-4	----
Maximally Exposed Noninvolved Worker	1E-8 (O)	4E-8 (H)	1E-4 (H)

[a] The probability of an LCF occurring in the MEI or maximally exposed noninvolved worker, and the number of LCFs in the population.
[b] H = Hanford, O = ORNL

5.1.10 Facility Accidents

This section describes potential impacts of facility accidents at the generator-storage sites from treatment of waste to the planning-basis WAC, at two of the generator-storage sites from waste storage after treatment, and at WIPP during waste management and disposal operations. Impacts from treatment accidents were evaluated for the six major generator-storage sites (Hanford, LANL, INEL, SRS, RFETS, and ORNL) that would treat about 98 percent of the total CH-TRU and RH-TRU waste under the Proposed Action.

Inhalation is the dominant exposure pathway for accidental releases of radionuclides and hazardous chemicals. Radiological impacts are potentially much greater than hazardous chemical impacts and are dominated by inhalation of transuranic radionuclides. Details of the methods and assumptions used in the accident analyses and complete accident scenario descriptions are provided in Appendix G.

5.1.10.1 Waste Treatment Accidents

Three potential waste treatment accidents were evaluated under the Proposed Action; they are presented in Table 5-15. Results are presented only for accidents involving CH-TRU waste. The results from these accidents would be greater than the results for similar accidents involving RH-TRU waste because CH-TRU waste contains greater concentrations of transuranic radionuclides (see Tables G-23 and G-24). The potential accident impacts at the six sites that would treat the greatest volume of CH-TRU waste were evaluated in detail; these sites would be Hanford, INEL, LANL, RFETS, ORNL, SRS. Impacts at LLNL, NTS, Mound, ANL-E, and

Table 5-15
Treatment Accident Scenarios for the Proposed Action

Accident Scenarios	Annual Occurrence Frequency	Description
Waste Spill (Accident Scenario T1)	0.01	Drum is mispositioned causing waste to spill onto the floor.
Drum Fire (Accident Scenario T2)	1E-4	Pyrophoric material inside a drum causes drum contents to burn.
Earthquake (Accident Scenario T3)	1E-5 or less	An earthquake stronger than that for which the building was designed (beyond-design-basis earthquake) collapses the roof of the building, causing drums to rupture and HEPA (High Efficiency Particulate Air) filters to fail.

other smaller sites were not evaluated because these sites would treat relatively small quantities of CH-TRU waste. Because of the small quantities, these sites would be expected to treat this waste (treatment to WAC is required prior to transportation) in small batches (e.g., 1 to 2 drum quantities at some sites). This treatment would not be expected to result in substantial impacts (i.e., no LCFs).

Treatment accident scenarios analyzed included a high-frequency/low-consequence operational accident expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a low-frequency/high-consequence beyond-design-basis accident involving a building collapse. Such an accident could potentially be precipitated by an earthquake, a plane crash, or a tornado; for the purposes of analysis in SEIS-II, the accident was assumed to be an earthquake. Accident analysis information is presented in Appendix G. The accidents analyzed are believed to be representative of the spectrum of potential accidents; different or additional accidents may be analyzed in past, ongoing, or future NEPA reviews or safety analysis reports.

While the annual occurrence frequency of a design-basis earthquake varies for DOE sites across the country (1×10^{-3} or less), the frequency of a beyond-design-basis earthquake that would result in loss of confinement and collapse the building has been estimated at 1×10^{-5} or less for purposes of these analyses. The analyses were conducted to estimate the difference in impacts among the types of waste treatment and not to make a decisions regarding specific treatment sites.

Estimated radiological impacts are presented in the text as the number of LCFs in the exposed population and the percent chance of an LCF occurring in MEIs (in the tables the probability of an LCF is presented for MEIs). Carcinogenic and noncarcinogenic impacts from hazardous chemicals, both VOCs and hazardous metals, also were estimated. Carcinogenic impacts are presented as the number of cancers in the exposed population and the percent chance of cancer for MEIs. Noncarcinogenic impacts from exposure to VOCs and hazardous metals were estimated by two different methods for the waste spill accident scenario (Accident Scenario T1) and drum fire scenario (Accident Scenario T2): IDLH-equivalent ratios and Emergency Response Planning

Guideline (ERPG) ratios. The potential noncarcinogenic impacts identified by ERPG ratios would be of minor importance during a beyond-design-basis earthquake and its consequent site-operations upheaval.

In general, potential radiological impacts would be higher than hazardous chemical impacts, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-16. Impacts to the maximally exposed involved worker were addressed qualitatively.

Public

Population impacts from treatment accidents were estimated for the exposed populations around the six major consolidation sites. Potential impacts to the population and MEIs at the six sites vary over a wide range because population distributions, the distances to the MEIs, and atmospheric dispersion factors differ among the sites. No LCFs would be expected in the exposed population from the waste spill or drum fire scenarios (Accident Scenarios T1 and T2, respectively), but 1 LCF was estimated to occur due to the earthquake (Accident Scenario T3). That LCF was estimated for ORNL. The radiological impacts were estimated to be the highest to the MEI at ORNL for all three accident scenarios. For the earthquake scenario (Accident Scenario T3) impacts to the MEI were estimated to range from a 4×10^{-4} (at SRS) to 0.08 (at ORNL) percent chance of an LCF.

Table 5-16
Radiological Impacts of Treatment Accidents for the Proposed Action[a]

Accident Scenarios	Population (Number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Waste Spill (Accident Scenario T1)	Maximum: 4E-4 (ORNL)	Maximum: 3E-7 (ORNL)	Maximum: 5E-7 (RFETS)
Drum Fire (Accident Scenario T2)	Maximum: 0.09 (ORNL)	Maximum: 7E-5 (ORNL)	Maximum: 9E-5 (RFETS)
Earthquake (Accident Scenario T3)	Hanford: 0.8 INEL: 0.04 LANL: 0.3 RFETS: 0.7 ORNL: 1.0 SRS: 0.8	Hanford: 2E-4 INEL: 1E-5 LANL: 4E-4 RFETS: 4E-5 ORNL: 8E-4 SRS: 4E-6	Hanford: 1E-3 INEL: 2E-4 LANL: 9E-4 RFETS: 2E-4 ORNL: 9E-4 SRS: 4E-4

[a] The site with the greatest impacts is shown in parentheses. Complete information about accident scenarios T1 and T2 for all sites is contained in Appendix G.

Depending on the treatment site, carcinogenic impacts from VOCs would be two to five orders of magnitude greater than impacts from hazardous metals for the waste spill and earthquake scenarios (Accidents T1 and T3, respectively) (see Appendix G). Hazardous metals would account for all carcinogenic impacts from the drum fire scenario (Accident Scenario T2) because VOCs would be consumed by the fire. No cancers were estimated to occur in the exposed population from the hazardous chemical releases of any accident. The maximum percent chance of cancer to the MEI would be 6×10^{-8} from any of the accidents. The ORNL MEI could develop irreversible or severe noncarcinogenic health effects from exposure to hazardous chemicals as a result of the events in the earthquake scenario (Accident Scenario T3).

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest impact outside of the waste treatment building. The impacts to the noninvolved worker were estimated to vary over two orders of magnitude across the six sites. Radiological impacts to the maximally exposed noninvolved worker would result in a 5×10^{-5} percent chance of an LCF from the events of the waste spill scenario (Accident Scenario T1), a 9×10^{-3} percent chance of an LCF from the events of the drum fire scenario (Accident Scenario T2), and up to a 0.1 percent chance of an LCF (at Hanford) from the beyond-design-basis earthquake (Accident Scenario T3).

No cancers would be expected from the release of hazardous chemicals or metals from any of the accidents; the greatest percent chance of cancer would be 9×10^{-8} (see Appendix G). If the events of the earthquake scenario should occur (Accident Scenario T3), the Hanford, LANL, and ORNL noninvolved workers would have chances of developing noncarcinogenic irreversible or severe health effects, but none of them would be life threatening. These effects would be expected from exposure to hazardous metals rather than VOCs.

Maximally Exposed Involved Worker

No impacts to the maximally exposed involved worker would be anticipated from the events in either the waste spill or drum fire scenarios (Accident Scenarios T1 and T2, respectively). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the events. Substantial impacts would be possible from the events of the earthquake

CRITICALITY

Criticality is defined as a state in which a self-sustaining nuclear chain reaction is achieved. The fissile material in the TRU waste that would be disposed of at WIPP would have to achieve a critical mass (the smallest mass of fissionable material that will support a self-sustaining nuclear chain reaction) in order to drive such a reaction. The minimum critical mass of a fissile material is the amount that can be made critical in a spherical geometry with optimum conditions. These conditions are considered incredible in the WIPP repository environment. Although TRU waste does contain fissile and fissionable material such as Pu-239, Pu-241, U-233, and U-235, previous DOE analyses have determined that a criticality event associated with CH-TRU waste is not a credible scenario. Indeed, the planning-basis WAC has established nuclear criticality criteria for both CH-TRU and RH-TRU waste that define the maximum allowable quantity of fissile material. These limits are defined in terms of Pu-239 fissile-gram equivalents and include a factor allowing for two times the measurement error when the waste packages are assayed. The planning-basis WAC allows up to 200 fissile-gram equivalents for a 55-gallon drum and 325 Pu-239 fissile-gram equivalents for the RH-72B cask, TRUPACT-II, ten drum overpack, and standard waste box.

Indeed, the primary difference between CH-TRU waste and RH-TRU waste is the inclusion of certain constituents, Cs-137 and its decay product Ba-137m, Am-241, Sr-90, and Co-60. These constituents, present in sufficient quantities, give a TRU waste container or cask a higher surface dose rate and, thus, the need to handle the waste container or cask remotely for worker protection. However, these constituents cannot support self-sustaining nuclear chain reaction and are not factors when determining the potential for criticality. In general, the components that affect criticality are more prevalent in CH-TRU waste than in RH-TRU waste. Therefore, criticality concerns associated with CH-TRU waste would provide bounding conditions for RH-TRU waste. Therefore, a criticality event involving RH-TRU waste is also considered incredible, although this type of accident is being further investigated.

The portion of the TRU waste Total Inventory that has a noteworthy concentration of radionuclides of concern (FGE) is the RFETS plutonium residue waste. On average, a drum of RFETS plutonium residue waste would contain 8.6 curies of Pu-239 and 50.5 curies of Pu-241 per drum which represents approximately 139 FGEs in a drum. These concentrations indicate that only two drums of RFETS plutonium residue waste could be shipped in a TRUPACT-II without exceeding the 325 fissile gram equivalent limit for a TRUPACT-II. Other drums could be transported as long as the FGEs remained within the limits of the WAC. No other source of TRU waste contains higher concentrations of fissile or fissionable isotopes.

scenario (Accident Scenario T3), ranging from workers killed by debris from collapsing treatment facilities to high external radiation doses from RH-TRU waste being treated. Intakes of radionuclides, VOCs, and hazardous metals would also be likely. If the involved worker survives the earthquake and roof collapse, the risk of developing a radiation-related LCF would be 20 percent. The percent chance of developing cancer from exposure to hazardous chemicals would not exceed 3×10^{-4}. Noncarcinogenic impacts to the involved worker would be substantial, leading to irreversible and even life threatening conditions.

5.1.10.2 Excess RH-TRU Waste Storage Accident

Under the Proposed Action only excess RH-TRU waste would be stored, and only at Hanford and ORNL. Lower transuranic radionuclide activity in RH-TRU waste (lower PE-Ci levels, see Table G-23 and Table G-24), lower RH-TRU waste volume, more robust waste containers for RH-TRU waste, and presumably more robust construction of RH-TRU waste storage facilities (thick concrete walls for external radiation shielding) would all combine to limit potential impacts from RH-TRU waste accidents.

Operational accidents involving storage of excess RH-TRU waste were estimated to have no or negligible impacts, so only the bounding case accident, a beyond-design-basis earthquake (with an

assumed annual accident frequency of 1 x 10^{-5} or less), was examined. The beyond-design-basis earthquake was assumed to collapse the RH-TRU waste storage facility. Five percent of the RH-TRU waste canisters were assumed to be breached, and 5 percent of the contents in the drums inside were assumed to spill. The respirable airborne fraction of the spilled contents was assumed to be 1 x 10^{-4}, and 25 percent of this fraction was assumed to escape the debris of the storage structure. In subsequent facility accident sections for the other alternatives, this accident scenario is designated Accident Scenario S3.

Radiological impacts would be much greater than hazardous chemical impacts and are shown in Table 5-17. Impacts would be greater at Hanford than at ORNL in all cases. Exposed populations could experience 3 x 10^{-3} (at ORNL) to 0.9 (at Hanford) LCFs, the MEI could have up to a 0.02 percent chance of an LCF (at Hanford), and the maximally exposed noninvolved worker could have up to a 0.2 percent chance of an LCF (Hanford).

Table 5-17
Radiological Impacts of an Excess RH-TRU Waste Storage Accident for the Proposed Action

Accident Scenarios	Population (number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Earthquake (Accident Scenario S3)	Hanford: 0.9 ORNL: 3E-3	Hanford:2E-4 ORNL: 2E-6	Hanford: 2E-3 ORNL: 3E-6

No cancer would be expected to occur from hazardous chemical exposure. The highest estimate of cancer in the population would be 1 x 10^{-4} from VOCs and 4 x 10^{-7} from hazardous metals near Hanford. The MEI near Hanford would have the highest percent chance of cancer occurring, 3 x 10^{-6} from exposure to VOCs and 1 x 10^{-8} from exposure to hazardous metals. The maximally exposed noninvolved worker would be located at Hanford as well, with a 2 x 10^{-5} percent chance of cancer from exposure to VOCs and a 9 x 10^{-8} percent chance of cancer from exposure to hazardous metals. No noncarcinogenic impacts would be expected.

Catastrophic destruction of the RH-TRU waste storage facility due to an earthquake could result in death or serious injury to the maximally exposed involved worker, principally from falling accident debris and radiation doses.

5.1.10.3 WIPP Disposal Accidents

Eight potential accidents at WIPP during disposal operations were evaluated; they are shown in Table 5-18. Six of the accidents involve only CH-TRU waste (Accident Scenarios W1 through W5 and W7), one involves only RH-TRU waste (Accident Scenario W8), and one was evaluated for impacts from both CH-TRU and RH-TRU waste (Accident Scenario W6).

Potential radiological impacts are substantially higher than hazardous chemical impacts, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-19.

Table 5-18
WIPP Disposal Accident Scenarios for the Proposed Action

Accident Scenarios	Annual Occurrence Frequency	Description
Drums Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	0.1	A package of drums is dropped in the Waste Handling Building, a drum on top of the package falls and its lid seal fails.
Drum Drop, Puncture, Lid Failure in Waste Handling Building (Accident Scenario W2)	0.01	Forklift strikes and punctures drums on lower level of stack in the Waste Handling Building. A drum on the upper level falls and the lid seal fails.
Drums Drop, Lid Failure in Underground (Accident Scenario W3)	0.01	Same as accident W1, but it occurs in the underground.
Drum Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	0.01	Same as accident W2, but it occurs in the underground.
Container Fire (Accident Scenario W5)	1E-4	Contents of a drum in an underground disposal room spontaneously combusts prior to panel closure.
Hoist Failure (Accident Scenario W6)	4.5E-7	Waste hoist braking system fails and fully loaded hoist falls to the bottom of shaft. Both CH-TRU and RH-TRU waste loads were evaluated.
Roof Fall (Accident Scenario W7)	0.01, Panel 1 9E-7, other panels	A portion of a disposal room roof falls prior to panel closure, crushing drums and causing lid seal failures.
RH-TRU Canister Breach (Accident Scenario W8)	1E-4 to 1E-6	RH-TRU waste canister is breached during Waste Handling Building operations.

Table 5-19
Radiological Impacts of WIPP Disposal Accident Scenarios for the Proposed Action

Accident Scenarios	Population (LCFs)	MEI (probability of LCF)	Maximally Exposed Noninvolved Worker (probability of LCF)	Maximally Exposed Involved Worker (probability of LCF)
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	9E-3	1E-4	1E-4	0.04
Drop, Puncture Lid Failure in Waste Handling Building (Accident Scenario W2)	0.02	2E-4	2E-4	0.07
Drop, Lid Failure in Underground (Accident Scenario W3)	7E-3	1E-4	8E-5	0.04
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	0.01	2E-4	1E-4	0.07
Container Fire (Accident Scenario W5)	0.06	9E-4	7E-4	N/A
Hoist Failure (CH-TRU, RH-TRU) (Accident Scenario W6)	CH-TRU: 4 RH-TRU: 1	CH-TRU: 0.07 RH-TRU: 0.02	CH-TRU: 0.05 RH-TRU: 0.02	See the text
Roof Fall (Accident Scenario W7)	0.2	2E-3	2E-3	See the text
RH-TRU Canister Breach (Accident Scenario W8)	4E-3	7E-5	5E-5	0

Public

Population impacts from WIPP disposal accidents were estimated for the 22.5 degree sector west of the site, which includes the City of Carlsbad. The population in this sector is 25,629 and would be impacted greater than any other section in the surrounding 80-kilometer (50-mile) region. Impacts to the MEI were evaluated at the point of closest public access to the DOE Exclusive Use Area boundary and the least atmosphere dispersion of facility exhaust ventilation air, which would be the location of maximum impact. This point was 300 meters (990 feet) south of the Exhaust Filter Building. No credit was taken for HEPA filtration from either the Exhaust Filter Building or the Waste Handling Building.

Radiological impacts from accidents would be higher than impacts from hazardous chemicals. The accident with the largest potential radiological impact to the population and the MEI would be the failure of a fully loaded waste hoist (Accident Scenario W6), which has a 95th percentile probability of occurrence of 4.5×10^{-7} per year (Greenfield and Sargent 1995). Up to 4 LCFs could occur in the exposed population, and the MEI could experience a 7 percent chance of an LCF. The roof fall accident (Accident Scenario W7) would result in the highest potential carcinogenic hazardous chemical impact, with an estimated 1×10^{-4} cancers occurring in the exposed population and an estimated 1×10^{-6} percent chance of cancer for the MEI. No fatalities due to toxicological effects would be expected, with the MEI estimated to inhale no more than of 2×10^{-3} percent of an IDLH-equivalent intake of any hazardous chemical under either the hoist failure or roof fall accidents. However, based on ERPG ratios, an extreme circumstance where the hoist fails while carrying a full load of drums all with bounding methylene chloride concentrations, serious health impacts might result. High concentrations of 1,1,2,2-tetrachloroethane could also produce serious, although not life-threatening, impacts from a hoist failure accident.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker at WIPP was assumed to be located at the location of least atmospheric dispersion, 300 meters (990 feet) south of the Exhaust Filter Building, which is the same location as the MEI. The stack that exhausts the underground ventilation is elevated and, as a result, the location of least plume dispersion is some distance from the release point. Radiological impacts shown in Table 5-19 may be slightly lower than those for the MEI because of the small difference in the radiation dose-to-LCF conversion factors for workers and members of the public. The hazardous chemical impacts would be identical to those of the MEI.

Maximally Exposed Involved Worker

The potentially highest impacts to an involved worker would be underground, from failure of a fully loaded waste hoist (Accident Scenario W6) or roof fall (Accident Scenario W7). These impacts could range from negligible (workers not present or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris). Four workers would be expected to be routinely involved in underground operations and potentially at risk from these accidents.

Radiological impacts of accidents to the maximally exposed involved worker from noncatastrophic accidents are shown in Table 5-19. The highest impacts would come from the drop, puncture, and lid failure accidents (Accident Scenarios W2 and W4), both with a 7 percent chance of an LCF. The highest hazardous chemical carcinogenic impacts to an involved worker were estimated to be from the accidental breach of three drums, with a 4×10^{-5} percent chance of cancer due to

inhalation of VOCs. No fatalities due to toxicological effects would be expected, with the highest percentage of the IDLH-equivalent intake being 0.4 percent for the breach of three drums (Accident Scenarios W2 and W4).

Based on ERPG analyses and conservative exposure assumptions, the involved worker might experience a life-threatening effect from exposures to high concentrations of methylene chloride from drum breaches (Accident Scenarios W1 through W4); irreversible, but not life-threatening impacts from high 1,1,2,2-tetrachloroethane; or minor, transient impacts from bounding carbon tetrachloride exposures.

5.1.11 Industrial Safety

Under the Proposed Action, four fatalities would occur during the waste treatment period from industrial accidents at all treatment sites. This result was found by adjusting the physical-hazard fatality estimate of the Draft WM PEIS.

At WIPP, the management and operating contractor has been awarded the star status in the DOE Voluntary Protection Program. This star status recognizes as "exemplary" the safety culture at the WIPP site. It is reciprocal with OSHA's Voluntary Protection Program star recognition. This star status indicates that the WIPP work force tends to have far fewer accidents and injuries than those at other DOE facilities. Regardless, estimates of potential industrial safety impacts to workers for proposed operations at WIPP were made using the average DOE occupational injury/illness and fatality rates shown in Table 5-20. DOE as a whole is well below the national average with respect to accident rates. DOE's average total recordable case (TRC) rate for 1988 to 1992 was 0.032 accidents per worker-year. The average TRC rate for private industry from 1983 to 1992 was 0.084 accidents per worker-year.

Table 5-20
Average Occupational Injury/Illness and Fatality Rates (per worker-year)[a]

Category	All Labor Categories (Operations)		Construction Workers (Excavation and Decommissioning)	
	Total Injury/Illness	Fatalities	Total Injury/Illness	Fatalities
DOE and Contractors[b]	0.032	3.2E-5	0.062	1.1E-4
Private Industry[c]	0.084	9.7E-5	0.13	3.4E-4

[a] Taken from DOE 1995b, Vol 2, Table F-4-7
[b] 1988-1992 averages from DOE (U.S. Department of Energy), 1993, "Occupational Injury and Property Damage Summary, January-March 1993," DOE/EH/015370-H2, March, Washington, D.C.
[c] 1983-1992 averages from NSC (National Safety Council), 1993, "Accident Facts," Itasca, New York.

For the purpose of estimating impacts, salt excavation activities were considered to be equivalent to construction activities, which have a higher rate of injury and illness than all other labor categories combined, and all other WIPP operations activities were considered jointly under all labor categories.

During the 35-year WIPP disposal operations period under the Proposed Action, the work force was assumed to remain constant at 1,095. Salt excavation would be undertaken by a crew of 10, with the remaining 1,085 workers employed in other operational activities. At the conclusion of operations, there would be a 10-year decommissioning period. For the purpose of estimating

industrial safety impacts during this 10-year period, it was assumed that the work force would decrease by 10 percent each year and that half of the work force would be involved in decommissioning activities equivalent to construction activities.

The estimated number of injuries/illnesses and fatalities among workers from operations, excavation, and decommissioning are shown in Table 5-21. Fewer than two worker fatalities would be expected from industrial-related occurrences during the 45 years of operations and decommissioning. Oversight and inspections by the Mining Safety and Health Administration (MSHA) and adherence to OSHA regulations would likely reduce actual occurrences below these estimated values.

Table 5-21
Industrial Safety Impacts from Operations and Decommissioning of WIPP Under the Proposed Action

Years	Injury/Illness			Fatalities		
	Construction	Operations	Total	Construction	Operations	Total
Operations 1998-2033	22	1,225	1,247	0.035	1.2	1.3
Decommissioning 2033-2043	187	96	283	0.3	0.1	0.4
Operations & Decommissioning Total	209	1,321	1,530	0.4	1.3	1.7

5.1.12 Long-Term Post-Closure Performance

This section provides a summary of the long-term radiological and hazardous chemical impacts of the WIPP disposal facility over the 10,000-year period after the site is closed. These impacts were based on a number of detailed simulations that predicted radionuclide and hazardous chemical releases both should the repository be undisturbed and should it be disturbed by drilling.

The conceptual and computational models used in the analyses were largely based on models and tools being used by the Department in current regulatory compliance analyses. The WIPP Program has been conducting analyses of long-term performance as a part of regulatory compliance with RCRA regulations and certification under 40 CFR Part 191 and 40 CFR Part 194. Although SEIS-II does not directly address these regulatory requirements, the scenarios analyzed in SEIS-II were chosen to represent the types of analyses that are being conducted for regulatory compliance applications.

The results computed here are complementary to those used for the *Draft No-Migration Variance Petition* (DOE 1995c) and the *Draft Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE 1996f). Results presented in SEIS-II used the same computer codes that are being employed for the regulatory compliance documents. The SEIS-II calculations are intended to be used for NEPA compliance purposes only. The methodology to be used in the final compliance certification application is still under review and may change before that application is submitted. The final SEIS-II will reexamine its long-term performance assessment in light of any changes in methodology adopted for the compliance certification application.

Analysis of the long-term impacts of WIPP was previously performed in SEIS-I. New analyses were deemed necessary in SEIS-II for the following reasons: (1) the current alternatives are different from those analyzed for SEIS-I in 1990, (2) the waste volumes and inventories for the Proposed Action and action alternatives are different from those used for SEIS-I in 1990, (3) new data have been collected for use in performance assessment models since 1990, and (4) substantial improvements have been made in the WIPP performance assessment approaches and computational tools (DOE 1996f). A discussion of all developments since SEIS-I is provided in Appendix H.

For the Proposed Action, the waste volumes were estimated to be 143,000 cubic meters (5 million cubic feet) for CH-TRU waste and 50,000 cubic meters (1.8 million cubic feet) for RH-TRU waste. For the purposes of analyses, the CH-TRU waste volumes were adjusted to 168,500 cubic meters (5.95 million cubic feet). Because of limits on RH-TRU waste currently permitted at WIPP, only 7,080 cubic meters (250,000 cubic feet) of the RH-TRU volume of waste were assumed to be emplaced under the Proposed Action. The radionuclide inventory was adjusted using the ratio derived from these volume changes. Other information on associated waste volumes and inventories is presented in Chapter 3 and in Appendix A.

The approach for SEIS-II had five major elements:

- The computational approach used deterministic analyses with a selected number of computer runs.
- Performance analyses were conducted using both median and 75th percentile values for model parameters.
- Both undisturbed and disturbed (i.e., human intrusion) conditions were analyzed.
- Numerical evaluation of performance was done using codes developed for WIPP.
- Results for long-term performance assessment were provided for the first 10,000 years after repository closure.

Though many parameters are employed for long-term performance assessment, only a small number have a potential impact on the estimate of contaminants released. Some of the important parameters include the solubility of contaminants in the waste form, sorption of contaminants on salt, hydraulic conductivity of the salt beds near the repository, and underground water travel times.

Performance estimates were calculated for median value conditions, as well as a more degraded scenario. The median value conditions were analyzed by using the median values of the statistical distributions that describe the input parameters for the full probabilistic analysis required by 40 CFR Part 194. Degraded performance was analyzed using the 75th percentile parameter values from the statistical distributions of the input parameters.

The use of median parameter values here means that the results are expected to fall in the middle of the results produced from a full probabilistic analysis. A model run using all median parameters would not yield the same result as the median output. The 75th percentile models and data used were intended to be conservative. The 75th percentile parameter values are used to yield model results that should fall in the upper tail of a full probabilistic analysis. They are not expected to yield higher impacts than the highest impact calculated from a full probabilistic analysis.

As discussed in the following sections, the results of this analysis indicate that there is remarkably little difference between the amounts of radionuclide and hazardous chemical releases from the repository when the analysis is conducted using both median and 75th percentile values. The results using the 75th percentile values provide slightly greater impacts in each case for the Proposed Action, as well as the action alternatives, and are presented in the figures in this chapter. For each alternative, the analysis of both median and 75th percentile values was conducted in order to demonstrate that the results are conservative.

Both undisturbed repository and disturbed repository conditions also were considered. Undisturbed conditions examined post-closure repository performance for 10,000 years with no human intrusion. Three types of disturbed conditions were considered:

- A drilling event that breaches the repository. This condition has the potential for causing a direct release of drill cuttings containing waste material from the repository to the land surface and exposing individuals involved in the drilling processes to radioactive material and hazardous chemicals.

- A drilling event that breaches the repository and penetrates a pressurized brine reservoir in the Castile Formation below the repository. This condition has the potential for allowing brine in the pressurized reservoir to come into contact with waste in the repository. The brine could then move further up the borehole to the more permeable units lying above the repository horizon like the Culebra Dolomite in the Rustler Formation. Such a release could lead to the migration of radionuclides and hazardous chemicals to off-site receptor points in the accessible environment.

- A mining event that removes potash from the geologic units overlying the repository. Potash mining has the potential of altering the hydraulic properties of overlying formations and units, including the Culebra Dolomite. If radionuclides and hazardous chemicals were to reach the overlying units, these changes in hydraulic properties could either increase or decrease groundwater travel times to off-site receptor points in the accessible environment.

Drilling intrusions analyzed in SEIS-I considered a family farm scenario that was assumed to be located 500 meters from the discarded drill cuttings. Currently, no farms exist near the WIPP site. Agricultural use of land in the region is primarily limited to cattle grazing due to poor soil conditions, a limited supply of stock-potable water, and no source of water for farming. Even if water were available, saline soil conditions make farming unlikely. For these reasons, the family farm scenario was not considered in SEIS-II analyses of drilling intrusion impacts.

The four cases below were analyzed under the Proposed Action. The cases considered the following conditions:

- Case 1 considered undisturbed repository conditions. Median parameter values were used for all input variables where probability distributions had been defined.

- Case 2 considered disturbed conditions resulting from an exploratory borehole that penetrates the repository and intercepts a brine pocket in the Castile Formation. Median parameters were used.

- Case 3 considered undisturbed repository conditions using 75th percentile parameter values for all input variables where probability distributions had been defined.

- Case 4 considered disturbed conditions resulting from an exploratory borehole that penetrates the repository and intercepts a brine pocket in the Castile Formation. 75th percentile parameters were used.

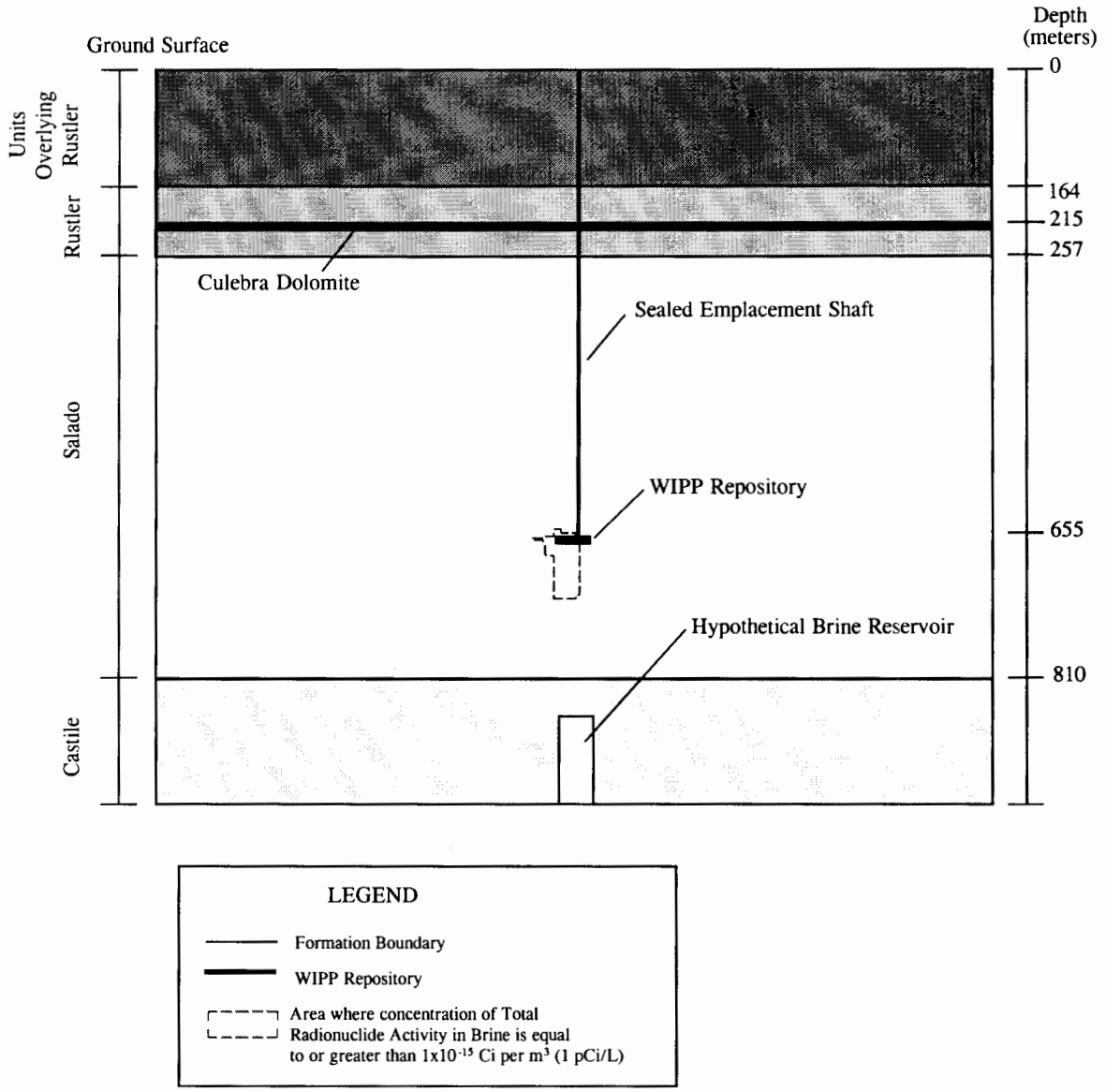
5.1.12.1 Impacts of the Undisturbed Repository Conditions

The nuclide transport system (NUTS) code was used to simulate radionuclide and hazardous metal transport using the time-varying brine and gas flow fields computed by BRAGFLO (see Appendix H). The two-dimensional modeling domain extended 23.3 kilometers (14.5 miles) laterally in each direction from the edge of the repository, and vertically from the Castile Formation below the repository to the ground surface. Detailed information is provided in Appendix H.

The extent of radionuclide and hazardous metal (lead, mercury, beryllium, and cadmium) migration for undisturbed conditions at 10,000 years after closure for Case 3 (using 75th percentile parameters) over the model domain is presented in Figure 5-1. Case 3 resulted in more extensive migration than Case 1. The dashed area in the figure indicates the location in the modeled region where the concentration of total radionuclide activity in the brine, summed over 30 radionuclides, is equal to or greater than 1×10^{-15} Curie (Ci) per cubic meter. This equates to a total radionuclide concentration of 1 picocurie (pCi) (1×10^{-12} Ci) per liter of brine. This same dashed area can also be used to evaluate the migration of hazardous metals from the repository. The area would approximately represent the extent of total hazardous metal concentration in brine that would be equal to or greater than 1×10^{-3} milligram per cubic meter of brine. This equates to a total hazardous metals concentration of 1 part per billion, which represents the totaled concentrations of lead, mercury, beryllium, and cadmium. However, because lead is by far the predominant hazardous metal in the analyzed inventory (see Appendix A), this total hazardous metal concentration can be interpreted to approximate the predicted concentration of lead only.

The total vertical scale of the modeled region is about 1,000 meters (3,280 feet). The horizontal extent of the modeled region represented in Figure 5-1 is approximately 47 kilometers (29 miles). The vertical scale is greatly exaggerated so the extent of vertical migration can be seen in the figure. Under the Proposed Action, simulation results showed total radionuclide concentrations of 1 pCi per liter and total hazardous metal concentrations of 1 part per billion at 10,000 years post-closure to extend 60 meters (200 feet) below the repository, 10 meters (33 feet) above the repository, and extend laterally about 1,200 meters (3,940 feet) from the edge of the repository.

Analysis of undisturbed repository conditions (Case 1 and 3) during the first 10,000 years concluded that: (1) no radioactive or hazardous metals would be released to the Culebra Dolomite, and (2) no radionuclide concentrations greater than 1 pCi per liter or hazardous metal concentrations greater than 1 part per billion would be found beyond the 5-kilometer (3-mile) subsurface lateral boundary. Therefore, the estimated human impact would be zero for undisturbed repository conditions under the Proposed Action. Detailed data for these model runs are provided in Appendix H.



Note: Results show the area of concentration extending 60 meters (200 feet) below the repository, 10 meters (33 feet) above the repository, and 1,200 meters (3,940 feet) laterally from the edge of the repository.

Figure 5-1
Extent of Radionuclide Migration at 10,000 years with Undisturbed Conditions (Case 3)

5.1.12.2 Impacts of Drilling into the Repository

In this scenario, a hypothetical exploratory drilling operation inadvertently penetrates a waste panel in the repository. DOE recognizes that during a 10,000-year period more than one borehole could penetrate the repository. The analysis here is for only one event. As a result of such a penetration, the drilling would bring waste originating in the repository to the land surface through a number of physical processes. These processes create cuttings (created by the cutting action of the drill bit), cavings (waste introduced into the borehole is eroded as drilling fluids move up or down the borehole), and spallings (waste and brine caused by the movement of repository gas to the low pressure conditions existing in the borehole). The generation of spallings in a borehole could be affected by very high-pressure repository conditions, causing waste to move into the borehole under blowout or direct gas erosion conditions.

The quantity of waste released would be dependent on repository gas- and brine-pressure conditions and the overall waste characteristics (primarily porosity and permeability) as the repository is initially breached by the exploratory borehole. The relationship of repository pressure and these release processes has been quantified and provides the basis for calculations of direct waste releases for the CUTTINGS_S computer code. The values of brine and gas pressure in the repository and the permeability of the waste used to determine the release process under this model were obtained from the fluid flow simulations performed with the BRAGFLO computer code. To maximize the impact of repository pressures, simulated brine and gas pressures were derived for undisturbed conditions calculated for Cases 1 and 3. The calculations of direct waste releases for the simulated BRAGFLO conditions were carried out using the CUTTINGS_S code.

Radiological and chemical impacts would be limited to individuals involved in the drilling operation. No population impacts were calculated because only small amounts of radioactive material would be brought to the surface, remain in a wet, relatively nondispersable form, and would remain localized. Impacts were estimated for two types of exposed individuals. These exposed individuals included:

- A member of a drilling crew directly involved in the exploratory borehole drilling. This individual would be exposed to external radiation from materials at the drill head and in the drill cutting pond and to inadvertent ingestion of small amounts of borehole material (100 milligrams per day). The drilling crew member was assumed to be exposed to the materials for a period of 168 hours (8 hours per day for a 21-day working period).

- A well site geologist involved in the periodic examination of cuttings generated by the drilling process. This individual would be exposed to external radiation through the direct handling of an exhumed fragment of waste; thus, only external dose calculations were performed for this exposed individual. The concentration of radionuclides in the exhumed waste fragment was assumed to be the emplacement concentration decayed to the time of intrusion. The geologist was assumed to pick up a cylindrical waste fragment 5 centimeters (2 inches) in radius with a volume of 524 cubic centimeters (32 cubic inches). An exposure time of one hour was assumed. If the well site geologist was assumed to ingest cuttings, the resulting dose would not exceed that of a drilling crew member.

This drilling intrusion under the Proposed Action was timed to maximize the estimated health impacts to exposed individuals. The earliest time that intrusion could occur was assumed to be 100 years after repository closure, the end of the active institutional control period. Because results of BRAGFLO calculations showed a steady increase in brine pressures in the repository (approximately 5 to 14 MPa) over the initial 1,000 to 1,200 years following repository closure, the

potential impact of repository pressure conditions on the release of materials up the borehole was examined. Results of radiation dose calculations for intrusion 100 years and 1,200 years post-closure demonstrated that less time for radioactive decay, rather than more time for the predicted increases in repository pressures, was the predominant factor in determining potential radiological impacts. As a result, impact analysis of the drilling intrusion under the Proposed Action (and all other action alternatives) assumed the intrusion occurred 100 years after repository closure, thereby providing maximum impacts. Details of this analysis are summarized in Appendix H.

Under the Proposed Action, estimated radionuclide releases to the ground surface during the drilling event for both Cases 2 and 4 were 8.8 Ci, mainly of Pu-238, Pu-239, and Am-241. Hazardous metal releases for Case 2 and Case 4 amounted to 18.7 kilograms and 1.6 kilograms, respectively, of lead and mercury for both median and 75th percentile parameter cases. These releases show that using median and 75th percentile parameter values resulted in approximately the same amount of material releases, activity releases, and doses for any given intrusion into the repository. This is an indication that hydrologic parameter changes to increase repository pressures and radionuclide transport would have minor effects on the impacts from intrusion. Only two parameters used for the intrusion analysis would have substantial impact on the results. These are the concentration of radionuclides in the repository material penetrated by the intrusion and the size of the intruding borehole. The inventory for each alternative is specified in Appendix A, and the size of the intruding borehole is specified by generally accepted practices. Detailed results of these analyses are provided in Appendix H.

Under the Proposed Action, the radiological impacts to a member of the drilling crew for Case 2 and Case 4 would be a 4×10^{-2} percent chance of an LCF, with 90 percent of the impact due to the inadvertent ingestion of drill cuttings and 10 percent due to external radiation dose. The radionuclide with the greatest impact contribution (approximately 87 percent) was Am-241. The impacts for Case 2 and Case 4 are the same because the intrusion would occur before any substantial transport would occur.

The drilling crew member would also be exposed to VOCs should the drilling event occur at a later time (e.g., 1,200 years post-closure) where a drilling mud blowout results from high gas pressures. In those cases, the drilling crew member would inhale some of the gas coming up the borehole for a short period of time before taking action to protect himself. The concentration of VOCs the driller would be exposed to would not be higher than the concentration at depth in the repository. The same sampling data used to derive the VOC concentrations in WIPP facility accidents were used to set time-invariant boundary conditions for the long-term performance assessment calculations. Therefore, the exposures for the drilling crew member would not be expected to be worse than those experienced in the bounding WIPP facility accident for the MEI or maximally exposed noninvolved worker. Based on information presented in Section 5.1.10, the hazardous chemical impacts would be a 4×10^{-5} percent chance of a cancer incidence and no noncarcinogenic health effects because only 0.4 percent of an IDLH-equivalent quantity would be inhaled.

The radiological impact to a well site geologist for Case 2 and Case 4 would be a 3×10^{-5} percent chance of an LCF, with about 99 percent of the impact attributable to RH-TRU waste. The only pathway considered was external dose, and Sr-90 and Cs-137 were the major radionuclides contributing to the impact. The impacts for Case 2 and Case 4 are the same because the intrusion would occur before any substantial transport would occur.

5.1.12.3 Impacts of Drilling Intrusion into Pressurized Brine Reservoir

In this scenario, a hypothetical deep drilling intrusion would introduce a high permeability (relative to the permeability of the intact salt) groundwater pathway from the repository to the near-surface Culebra Dolomite. Contaminants could migrate up the intrusion borehole and move laterally through the Culebra Dolomite. A cattle rancher was assumed to locate a stock well at the nearest down-gradient location that has stock-potable water (water with no more than 10,000 milligrams per liter of dissolved solids). As in SEIS-I, the stock well was assumed to be located 5,000 meters (3 miles) south of the center of the WIPP site. The drilling location was assumed to be at the center of the Land Withdrawal Area.

Because current drilling practices are to plug all deep boreholes in the Delaware Basin (Thompson et al. 1996), it was assumed for the purposes of SEIS-II analyses that all deep intrusion boreholes would be plugged. The assumption was made that a plugged borehole has low permeability concrete plugs that degrade after 200 years. Further details on the hydrologic properties of the plugged borehole are given in Appendix H.

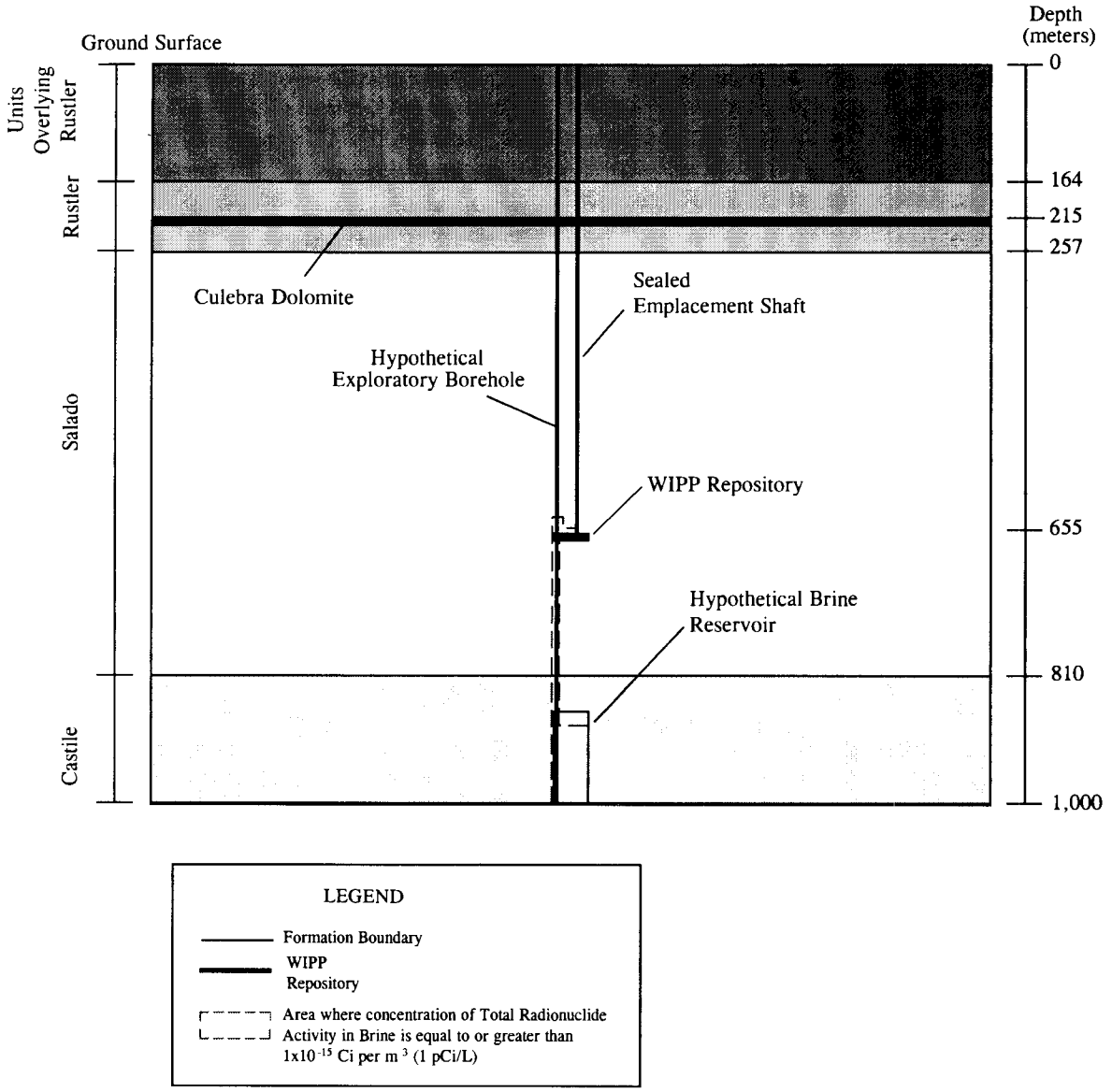
The extent of radionuclide and hazardous metal (predominantly lead) migration at 10,000 years after closure for Case 4 (using 75th percentile parameters) is schematically presented in Figure 5-2. Total radionuclide concentrations of 1 pCi per liter and hazardous metal concentrations of one part per billion are shown. Simulations showed radionuclides and metals migrated upward and downward into the exploratory borehole and penetrated into rocks directly in contact with the borehole for a limited distance. At 10,000 years, migration extends upward in the borehole about 20 meters (66 feet) above the repository. Migration also extends downward in the borehole to the Castile Formation and into the brine reservoir. This occurs after the initial pressure in the pressurized brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole over the 10,000-year simulation. Predicted brine pressures and other modeling details associated with this simulation are provided in Appendix H.

No radionuclides or hazardous metals would be released into the Culebra within 10,000 years of repository closure for the deep drilling scenario under the Proposed Action. Therefore, there would be no impact to the cattle rancher.

5.1.12.4 Impacts of Potash Mining

The impacts of potash mining on long-term performance of the repository was examined for the Proposed Action. 40 CFR Part 194, which provides regulatory guidance on the assessment of mining events, suggests that the net effect of mining can be evaluated in long-term compliance analyses by assessing off-site impacts of increasing the hydraulic conductivities of key hydrogeologic units. Increasing the hydraulic conductivity of key units would change estimates of groundwater travel time and predicted concentration levels at receptor locations in the accessible environment.

The approach developed for the Proposed Action (and the other action alternatives) was to examine the impacts of changing the hydraulic conductivity of the Culebra Dolomite should releases from the repository reach the Culebra in simulations of undisturbed and disturbed conditions of the repository. The Culebra is considered the most significant hydrogeologic unit above potential mined zones and the repository from the standpoint of off-site transport to the accessible environment. Following guidance provided in 40 CFR Part 194, travel time increases based on changing the hydraulic conductivity of the Culebra Dolomite by a factor of 1,000 were developed using the areal two-dimensional model of the Culebra being implemented in the *Draft Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant*



Note: Results show the area of concentration extending upward 20 meters (66 feet) and downward to the Castile Formation and into the brine reservoir.

Figure 5-2
Extent of Radionuclide Migration at 10,000 years with Human Intrusion Conditions (Case 4)

(DOE 1996f). However, results for the Proposed Action (and other action alternatives) indicated that radionuclide and hazardous chemical releases from the repository would not reach the Culebra Dolomite for either undisturbed or disturbed (borehole intrusion into the repository and a pressurized brine reservoir) conditions. Thus, the impacts of potash mining on long-term performance, as suggested in 40 CFR Part 194, were not evaluated further for the Proposed Action or other action alternatives.

5.1.12.5 Impacts of Storage of Excess RH-TRU Waste

DOE would continue to store excess RH-TRU defense waste beyond the WIPP authorized disposal capacity at Hanford and ORNL under the Proposed Action. Continued storage of this waste would be expected to result in less than the maximum 2 worker deaths that might be expected from storage of all of the Department's TRU waste for each 100 years of storage. If the waste were released, it would be expected to cause less than 2 deaths over a 10,000-year period, assuming current population distributions. However, should the Hanford and ORNL sites become densely populated over the 10,000-year period, substantially more deaths could result, especially at Hanford.

5.2 IMPACTS OF ACTION ALTERNATIVE 1

This section describes the environmental impacts associated with implementation of Action Alternative 1. This alternative proposes treating waste to WAC[1], consolidating the waste at the same sites discussed under the Proposed Action, and disposing of the waste at WIPP. In addition to the Basic Inventory, WIPP would accept nearly all other DOE-controlled waste (i.e., the Additional Inventory without the waste commingled with polychlorinated biphenyls [PCB]). The treatment time frame would remain at 35 years. Though additional waste would be treated under this alternative, the treatment time period would be three and a half times that assessed in the Draft WM PEIS. The total consolidated volume of waste to be treated under this alternative is 312,000 cubic meters (11 million cubic feet) (see Tables 3-2 and 3-3), less than three times the 110,000 cubic meters (3.9 million cubic feet) assessed in the Draft WM PEIS. The WIPP operational time frame would extend to the year 2158 (160 years) so that the additional waste could be emplaced.

Where appropriate in the following sections, analyses include assessment of the impacts of storage of treated TRU waste before disposal. For the purposes of this document, this storage is called lag storage. Analyses in Action Alternative 1 also include a qualitative assessment of the impacts of rail transportation. A detailed description of Action Alternative 1 is given in Section 3.2.2.

5.2.1 Land Use and Management

At the treatment sites, land use impacts under Action Alternative 1 would be the same as those under the Proposed Action. The type, size, and number of treatment and consolidation facilities needed under this alternative would be comparable to those for the Proposed Action. The Department would be able to minimize impacts to on-site land use and avoid conflicts with off-site land use plans. It also would be able to avoid sensitive or inappropriate areas, including cultural resource areas, the habitats of threatened or endangered species, wetlands, and flood plains. Before treatment facilities would be constructed, further NEPA reviews would be undertaken at a site-wide or project-specific level.

[1] For purposes of analysis, the current planning-basis WAC was used.

LONG DISPOSAL PERIODS AND SEIS-II RESULTS

The action alternatives examined in SEIS-II have waste disposal periods that are much different from the 35-year disposal period of the Proposed Action. Action Alternative 1, all of the Action Alternative 2 subalternatives, and Action Alternative 3 have 160-, 150-, and 190-year disposal periods, respectively. There are three main reasons for these long disposal periods. First, it was assumed that the aboveground configuration of WIPP (principally, the Waste Handling Building and underground access shafts) remains unchanged for all alternatives so waste handling and waste emplacement rates are the same. Second, the waste volumes to be disposed of under the action alternatives would be much greater than the Proposed Action. Third, the final waste form after treatment would affect the volume and heat generation rate of the waste and its ability to meet the WIPP design criteria for thermal loading in the repository.

The large volume of RH-TRU waste in the SEIS-II inventory and the relatively small WIPP throughput rate for RH-TRU waste (8 RH-72B casks per week) are the main reasons for the longer disposal periods for Action Alternatives 1 and 3. Alternative 3 waste volumes would also be increased because of the shred and grout treatment. The disposal period for each Action Alternative 2 subalternative would be increased mainly because of the time required to excavate additional underground panels for RH-TRU waste emplacement. The thermally-treated waste form would have greater radioactivity per volume and thus would have to be distributed over a wide area to meet WIPP thermal loading design criteria.

Assuming the same aboveground WIPP configuration for all action alternatives means that *annual* descriptive parameters and *annual* impacts from TRU waste disposal would be very similar. For example, the same annual work force would be required, the annual WIPP budget would remain the same, and the same annual waste throughput limitations would exist which, as noted above, are particularly important for RH-TRU waste. *In many cases, differences between alternatives are better reflected in long-term, aggregate impacts*. For example, SEIS-II presents aggregate transportation impacts over the entire transportation period, life-cycle costs, socioeconomic impacts over the entire disposal period, lifetime human health impacts, and long-term performance assessment of impacts over the maximally exposed lifetime within the assessment period (if such impacts occur). For these analysis areas, comparing long-term aggregate impacts across alternatives provides more information than comparing annual impacts and better reflects key differences in waste volume and waste treatment methods among alternatives.

At WIPP, land use impacts on the surface during disposal operations under Action Alternative 1 would be similar to those under the Proposed Action discussed in Section 5.1.1. These impacts would be similar because the surface facilities would be the same as those for the Proposed Action. One difference from the Proposed Action would occur during the decommissioning and closure process; approximately 295 hectares (730 acres) would be affected due to an increased underground waste disposal area. This area would be included in the bermed and permanently marked area once closure was begun. Like the Proposed Action, the rest of the Land Withdrawal Area would be available to the public for nonintrusive surface activities following decommissioning and closure. Restrictions on slant drilling would continue.

5.2.2 Air Quality

At the treatment sites, the potential annual air quality impacts would not differ substantially from those presented for the Proposed Action in Section 5.1.2. The only criteria pollutant postulated to exceed 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be CO at RFETS (17 percent), the same as for the Proposed Action. RFETS, LLNL, and ANL-E are in nonattainment areas for some pollutants. In nonattainment areas, activities that introduce new sources of emissions are regulated under the General Conformity

Rule. In attainment areas, regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources which will result in emissions equal to or greater than the limits set by pertinent regulations. No hazardous or toxic air pollutants would exceed 10 percent of the applicable regulatory standard (see Appendix C for additional details) (DOE 1995f). Potential minor emissions of PM_{10} may occur during construction.

At WIPP, the potential annual air quality impacts under Action Alternative 1 would be the same as those anticipated under the Proposed Action. Although the increased waste disposal volume would increase the duration of disposal activities, there would be no substantial differences in the rates of pollutant emissions on an annual or short-term basis.

The potential air quality impacts due to the decommissioning of WIPP under Action Alternative 1 would be similar to those anticipated under the Proposed Action. Because the waste disposal area would increase, the construction of berms and permanent markers and other decommissioning activities would take longer; these activities, though, would still be within the 10-year decommissioning period. Thus, there would be no substantial difference in the rate of pollutant emissions.

5.2.3 Biological Resources

The potential impacts on biological resources at the treatment sites under Action Alternative 1 would be the same as those under the Proposed Action described in Section 5.1.3. Threatened and endangered species may be present at all of the proposed treatment sites and could potentially be impacted; however, whether there would be impacts depends on the actual location of the facility at a particular site. Site selection would be conducted following site-wide or project-level NEPA review during which such impacts would be assessed and mitigated as necessary. Endangered, threatened, or proposed species and all critical habitats would be avoided and appropriate consultation, monitoring, and mitigation measures would be undertaken as necessary. The longer treatment period proposed for Action Alternative 1 is not expected to have any additional impact to species over the life of the campaign. Analyses also determined that terrestrial wildlife species would not be affected by airborne emission from waste management or treatment facilities nor from spills of TRU waste into aquatic environments due to traffic accidents (DOE 1995f).

Federally listed, threatened and endangered, and state-listed species occur in Eddy County and potentially at the WIPP, although DOE has not observed threatened, endangered, or proposed species or critical habitats at the WIPP site during surveys conducted for recent biennial environmental compliance reports. DOE is conducting a survey to update the list of species at the site and will consult with these agencies once the survey is completed.

At WIPP, the potential impacts on biological resources under Action Alternative 1 would be similar to those under the Proposed Action (described in Section 5.1.3) except for impacts resulting from the increased underground waste disposal area. A total of 295 hectares (730 acres) of aboveground area would be disturbed during salt pile reclamation and construction of berms and permanent markers during closure. These activities would disturb avian and small mammal habitat. These areas would be attractive after natural vegetation recolonizes.

FACTORS TO CONSIDER IN COMBINING ALTERNATIVES

When considering whether to implement a combination of alternatives, it is important to identify factors that lead to differences in impacts. How impacts change in relation to several factors is examined here.

WASTE VOLUME: In general, impacts (particularly treatment and transportation impacts) vary directly according to waste volume. The greater the waste volume, the greater the impacts. Preliminary figures from recent data indicate that projected waste volumes through 2033 could be lower than Baseline Inventory Report, Revision 2 (BIR-2) projections through 2022 by about 30,000 cubic meters for CH-TRU waste (which translates to a decrease of about 34,000 cubic meters from SEIS-II 2033 CH-TRU waste projections) and about 20,000 cubic meters for RH-TRU waste (which translates to a decrease of about 25,000 cubic meters from the SEIS-II 2033 RH-TRU waste projections). The accuracy of these projections depends, in part, on remediation decisions that would be made in the future and the effect these decisions could have on the timing of TRU waste generation. Much of this potential decrease could result if DOE were to decide to leave some of the instrumentation and machinery related to facilities with high radiation levels (such as instrument trees, and mixer pumps in the Hanford high-level waste tanks, which are projected to be RH-TRU waste when removed from the tanks) in place at those facilities until the facilities themselves are remediated, thus resulting in reduced TRU waste generation through 2033. This decrease would not affect waste volumes proposed to be disposed of under the Proposed Action and would not affect the analysis of the impacts of that action, except that impacts from storage of excess RH-TRU waste would decrease. The waste volumes for alternatives that involve disposing of all of the waste could be reduced by about 10 percent for CH-TRU waste and about 40 percent for RH-TRU waste. Impacts directly related to waste volume may be reduced for the action alternatives that consider disposing of all DOE TRU waste, including transportation impacts and accident free waste treatment impacts. The need to dispose of a lower volume of TRU waste could reduce operational time periods for the alternatives by about 50 (Alternative 2) to about 75 years (Alternative 3) and would also reduce the land area above the repository that would be impacted by closure activities. Accident impacts would not be reduced, but the shorter operational time periods could mean that some accidents would be less likely to happen during that time period. The lower waste volumes would not affect the ability of WIPP to isolate the waste once it is disposed of.

WASTE TREATMENT: Health impacts related to treatment for both workers and the public in the short-term increase as the complexity of waste treatment increases. Treatment to planning-basis WAC has the least impact, followed by shred and grout treatment, with thermal treatment having the highest treatment related impacts of the three treatment alternatives examined.

WASTE MANAGMENT: The long-term impacts of disposal at WIPP are lower than the long-term impacts of the waste storage. This is particularly true when loss of institutional control of the waste is assumed. Also, industrial accidents would lead to substantial impacts if waste were stored for long time periods.

WASTE TYPE (CH-TRU or RH-TRU): Transportation of RH-TRU waste would have relatively greater transportation impacts than CH-TRU waste primarily because of the smaller volume of RH-TRU waste per shipment which increases the number of shipments required to move the RH-TRU waste. Otherwise, on a per unit volume basis, the impacts from treatment and storage of RH-TRU waste are less than those for CH-TRU waste.

TRANSPORTATION MODE: Overall, regular rail transportation would have the least impacts, truck transportation impacts would have about 2 to 3 times that of regular rail service, and dedicated rail service would be about 23 times those of regular rail transportation.

DURATION OF ALTERNATIVE: Longer durations would spread the impacts out over more generations, exposing more people to potential impacts; the risk to each population therefore, would be less. Shorter durations would expose fewer people to potential impacts, the risk to each population would be slightly higher.

5.2.4 Cultural Resources

At the treatment sites, the potential impacts on cultural resources are expected to be the same under Action Alternative 1 as for the Proposed Action. This is because the size and number of the facilities would be the same as those assessed for the Proposed Action. The construction and operation of TRU waste treatment facilities could adversely affect cultural resources; however, site-level cultural resource surveys would be conducted and protection measures would be established, where necessary, when specific facility construction locations are proposed (DOE 1995f). These surveys would be part of site-wide or project-level NEPA reviews. Sacred sites and burials would be avoided when siting the facilities, and appropriate consultation would be undertaken during the reviews.

At WIPP, all of the surface area included under Action Alternative 1 has been inventoried for cultural resources as part of the initial survey of the 1,040-hectare (4-square mile) central WIPP site. Eleven prehistoric archaeological sites (LA14307, LA14308, LA33155, LA33156, LA33157, LA33159, LA33160, LA33163, LA33170, LA33179, and LA33180) are located in the previously surveyed areas within Sections 28 and 29, T. 22S, R. 31E. Each of these sites was evaluated by the original investigators as being potentially eligible for inclusion in the NRHP (DOE 1995d).

TRU waste shipping and operational activities at WIPP would not have an impact on these or other archaeological sites. Depending on final project design, some of these archaeological sites could be affected by closure and decommissioning-related activities. Surface ground disturbance for construction of long-term decommissioning features such as various types of markers, earthen berms, and informational centers could impact some archaeological sites.

Measures for ensuring protection of known archaeological and historic resources (or others that may be inadvertently discovered during ground-disturbing activities) are discussed in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1996b). These measures include identifying, inventorying, evaluating, and treating cultural resources under the National Historic Preservation Act of 1966. DOE will avoid, to the extent possible, sites found eligible for inclusion in the NRHP. Where avoidance is not possible, mitigation measures will be developed in consultation with the State Historic Preservation Office, Advisory Council on Historic Preservation, and the BLM.

5.2.5 Noise

Treatment facilities would probably be located in industrial areas along high-volume roadways, and, therefore, ambient noise levels would not increase substantially (DOE 1995f). Sensitive receptors, however, may be impacted. Further analysis has been reserved for site-wide or project-level NEPA review (DOE 1995f). Because all waste would travel to WIPP but only a portion of the waste would travel to or from each treatment facility under this alternative, the greatest impacts due to transportation noise would be near the WIPP site and are discussed below.

At WIPP, potential noise impacts under Action Alternative 1 for truck transportation and operations would be similar to those described under the Proposed Action in Section 5.1.5. This is because the throughput rate was assumed to remain the same (50 TRUPACT-IIs and eight RH-72B casks per day). The trucks would still arrive at random times throughout the day.

Unlike the Proposed Action, Action Alternative 1 examines rail transportation. All rail transportation of TRU waste destined for WIPP would travel through Carlsbad, New Mexico, to Loving, New Mexico, where it would be diverted to WIPP via a dedicated spur. Rail noise may be disruptive to certain public and private institutions. The commercial rail noise impact would

result from the addition of rail cars carrying TRUPACT-IIs or RH-72Bs to existing commercial trains. A single rail car may carry up to six TRUPACT-IIs or two RH-72Bs. The noise impact would be a slight increase in the duration of propagated noise resulting from trains passing through the affected communities. The estimated impact would depend on the speed of the rail car and the total number of rail cars. Use of dedicated trains would result in increased rail traffic through Carlsbad and Loving and would be potentially more disruptive than use of commercial rail. Assuming each dedicated train contained three fully loaded rail cars, four additional trains could pass through these cities each week, averaging less than one additional train per day. Therefore, the overall noise impact would be negligible.

5.2.6 Water Resources and Infrastructure

Because the SEIS-II operations time would be three and a half times longer and the volume of waste treated less than three times higher than that anticipated under the Draft WM PEIS, the size of the treatment facilities needed for Action Alternative 1 would be comparable, if not smaller, than those analyzed for the Draft WM PEIS. Therefore, the incremental impacts to site infrastructure are estimated to be the same as those reported in the Draft WM PEIS.

Although no off-site infrastructure impacts are expected to occur, proposed TRU waste activities at the treatment sites would affect on-site activities, including the capacities of on-site water, power, and wastewater systems, and on-site transportation. The impacts would be the same as those for the Proposed Action. Only Hanford would show an increase in on-site demand for wastewater that would exceed five percent of current demand (5.9 percent). Major impacts to water resources at the treatment sites would be unlikely (DOE 1995f).

Minor impacts to the on-site transportation infrastructure are expected under the Action Alternative 1. These impacts are a result of an increase in on-site employment of 6 percent at Hanford and INEL and 7 percent at LANL. Impacts to the off-site transportation infrastructure are not anticipated because population increases do not exceed 5 percent (DOE 1995f).

At WIPP, negligible annual infrastructure impacts would be expected under Action Alternative 1. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

5.2.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for Action Alternative 1 are presented in the following subsections.

5.2.7.1 Life-Cycle Costs

Life-cycle costs under Action Alternative 1 are presented in Table 5-22 for three areas: treatment facilities, waste transport, and WIPP disposal operations. Waste treatment facility costs include construction, O&M, and D&D at the treatment sites. For the purposes of SEIS-II analyses, it was assumed that the treatment sites would process, treat, and package waste to planning-basis WAC over a period of 35 years (as in the Proposed Action, but for larger waste volumes). Correspondingly, sites with large volumes (INEL, Hanford, and ORNL) would be required to store portions of the treated waste volumes over some or all of the 160-year disposal period, mainly due to RH-TRU waste throughput limitations at WIPP. The waste treatment facility life-cycle costs would be $21.4 billion (in 1994 dollars).

Table 5-22
Life-Cycle Costs Under Action Alternative 1
(in millions of 1994 dollars)[a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	8,400	3,100	11,500	8,800	1,000	9,800	21,400	11,900
Transport by Truck	847	2,900	3,700	881	285	1,200	4,900	780
Transport by Regular Rail	666	171	837	697	16	713	1,600	250
Transport by Dedicated Rail	4,900	1,200	6,100	5,100	113	5,200	11,300	1,800
Disposal at WIPP	10,600	2,700	13,300	11,100	248	11,300	24,600	3,700
Total Life-Cycle Cost (Truck Transport)	19,800	8,700	28,500	20,800	1,500	22,300	50,500	16,300
Total Life-Cycle Cost (Regular Rail)	19,700	6,000	25,600	20,600	1,300	21,900	47,500	15,800
Total Life-Cycle Cost (Dedicated Rail)	23,900	7,000	30,900	25,000	1,400	26,400	57,300	17,300

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

Action Alternative 1 considers three waste transportation options from the treatment sites to WIPP: (1) trucks only, as in the Proposed Action, (2) trucks with maximum regular (commercial) rail service, and (3) trucks with maximum dedicated rail service. Under transportation options 2 and 3, rail routes would be used to the greatest extent practical. LANL and NTS would be the two exceptions because there are no rail routes to these sites; thus, their waste would be entirely transported by truck. Under these options, the transportation costs reflect consolidation of the waste volumes at the treatment sites and shipment of the treated volumes via truck or rail to WIPP for emplacement. The waste transport life-cycle costs would be $4.9 billion by truck, $1.6 billion by regular rail, and $11.3 billion by dedicated rail.

The WIPP life-cycle costs would be $24.6 billion. The total life-cycle costs for the Total Inventory under Action Alternative 1 would be $50.9 billion ($16.3 billion when discounted) using truck transportation, $47.5 billion ($15.8 billion when discounted) using regular rail transportation, or $57.3 billion ($17.3 billion when discounted) using dedicated rail transportation.

5.2.7.2 Economic Impacts

Treatment activities would result in creation of additional direct, indirect, and induced jobs. Under Action Alternative 1 approximately 11,700 jobs would be created in the ROIs of the 10 major treatment sites (ANL-E, Hanford, INEL, LANL, LLNL, Mound, NTS, ORNL, RFETS, SRS).

Within the WIPP ROI, estimates of the impacts of Action Alternative 1 on employment, income, and the production of goods and services are presented in Table 5-23. These regional impacts are estimated using an annual average project budget of $180 million per year over a 160-year waste disposal period. During this extended period of waste emplacement operations, the WIPP facility would remain a stable federal employer in the ROI economy by providing direct employment for 1,095 project personnel annually. Indirectly, the operation of WIPP (from 1998 through 2158) would annually support 2,276 jobs in the ROI work force. Total annual WIPP-induced employment within the ROI would be 3,371, reflecting the sum of these direct and indirect employment levels.

Table 5-23
Economic Impacts within the ROI Under Action Alternative 1

Economic Effect	Employment (Full- and Part-Time Jobs)	Output of Goods and Services (in millions of 1994 dollars)	Labor Income (in millions of 1994 dollars)
Direct - Annual	1,095	180	50
Indirect and Induced - Annual	2,300	330	70
Total - Annual	3,400	500	120
Total - Operations (160 years)	539,400 job years	80,800	19,200
Total - Operations (Discounted)	N/A	12,400	2,900

N/A = Not Applicable

Because the projected average annual project budget is close to historical levels, Action Alternative 1 would not be expected to result in additional use of government-provided goods or services (schools, police, fire protection, and health protection) nor require major capital investments in public infrastructure within the ROI. For this same reason, Action Alternative 1 would not be expected to impact the local real estate markets nor result in major changes in the work force population.

5.2.8 Transportation

This section presents the transportation impacts for Action Alternative 1. Treatment and consolidation of TRU waste and the radionuclide and hazardous chemical concentrations in the waste are the same for truck transportation in the Proposed Action and Action Alternative 1; therefore, the differences between the transportation impacts are due solely to the increased number of shipments under Action Alternative 1. Rail transportation impacts for both regular and dedicated train options for Action Alternative 1 are presented at the end of this section.

5.2.8.1 Route Characteristics and Shipment Projections

The methods used to determine route characteristics and the number of shipments were identical to the approach presented in Section 5.1.8.1. Table 5-24 presents the number of shipments required under Action Alternative 1. Because the consolidation and treatment of waste would be the same for the Proposed Action and Action Alternative 1, the mileage for each route would also be the same (see Table 5-5).

5.2.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation

The total number of accidents, injuries, and fatalities over the transportation period of 160 years for Action Alternative 1 are shown in Table 5-25. For Action Alternative 1, a total of 237 accidents, 148 injuries, and 19 traffic-related fatalities were estimated. Also shown in Table 5-25 are the estimated cancer fatalities attributed to diesel exhaust (pollution health effects). These effects are based upon the total miles traveled in an urban area and 9.9×10^{-8} LCFs per kilometer (1.6×10^{-7} per mile) (Rao et al. 1982).

The impacts of shipping waste from the small quantity sites to the larger treatment sites were estimated by scaling the number of miles traveled to consolidate the waste against the total miles traveled for shipment to WIPP. The adjusted results are included in Table 5-25.

Table 5-24
Number of Truck Shipments to WIPP Under Action Alternative 1[a]

Waste Treatment Site	CH-TRU Waste			RH-TRU Waste		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
Argonne National Laboratory - East	24	---	24	---	---	---
Hanford Site	11,562	7,167	18,729	47,156	1,651	48,807
Idaho National Engineering Laboratory/ANL-W	4,892	6,474	11,366	3,136	711	3,847
Lawrence Livermore National Laboratory	137	---	137	---	---	---
Los Alamos National Laboratory	4,238	1,590	5,828	367	190	557
Mound Plant	50	23	73	---	---	---
Nevada Test Site	73	---	73	---	---	---
Oak Ridge National Laboratory	212	8	220	5,875	3,076	8,951
Rocky Flats Environmental Technology Site	2,102	---	2,102	---	---	---
Savannah River Site	1,893	558	2,451	---	---	---
Total	**25,183**	**15,820**	**41,003**	**56,534**	**5,628**	**62,162**

[a] The number of shipments from sites with smaller quantities can be found in Appendix E. There would be 55 CH-TRU waste shipments and 1,350 RH-TRU waste shipments. Impacts from the transportation of TRU waste to the treatment sites is small relative to the 10 major generator-storage sites above (see Appendix E).

Table 5-25
Nonradiological Impacts of Transporting TRU Waste by Truck Under Action Alternative 1

Impact	CH-TRU Waste			RH-TRU Waste			Total		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
Number of Accidents	49	34	83	142	12	154	191	46	237
Number of Injuries	32	21	53	87	8	95	119	29	148
Number of Fatalities	4	3	7	11	1	12	15	4	19
Pollution Health Effects (fatalities)	0.1	0.08	0.2	0.3	0.03	0.3	0.4	0.1	0.5

5.2.8.3 Accident-Free Radiological Impacts from Truck Transportation

Accident-free radiological impacts occur during routine transportation and are the result of public and worker exposure to direct radiation at levels allowed by transportation regulations. The methods used to determine accident-free radiological impacts for Action Alternative 1 were identical to those described for the Proposed Action.

Table 5-26 presents a summary of the accident-free population radiological impacts for Action Alternative 1. Approximately 0.7 occupational LCFs and 10.6 nonoccupational LCFs would be expected in the exposed population groups.

Table 5-26
Aggregate Accident-Free Population Radiological Impacts from Truck Transportation Under Action Alternative 1 (LCFs)[a]

Exposure Category	CH-TRU Waste			RH-TRU Waste			TOTAL		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
Occupational	0.2	0.2	0.4	0.3	0.02	0.3	0.5	0.2	0.7
Nonoccupational									
Stops	1.7	1.1	2.8	6.5	0.6	7.1	8.2	1.7	9.9
Sharing Route	0.1	0.07	0.2	0.4	0.03	0.4	0.4	0.09	0.5
Along Route	0.04	0.02	0.06	0.1	0.01	0.1	0.2	0.04	0.2
Nonoccupational Total	1.8	1.2	3.0	7.0	0.6	7.6	8.8	1.8	10.6

[a] Exposure during stops is based upon 50 individuals exposed at 20 meters. Stop time, in hours, is based upon 0.011d where d is the distance traveled in kilometers. These parameters are built into the RADTRAN code but substantially overestimate exposures from WIPP shipments. Because WIPP shipments would use 2-driver teams (eliminating the need for overnight stops to sleep) and because the shipments would stop at sites chosen, in part, for their lack of population, the actual impacts from stops would be much lower.

The accident-free radiological impacts of shipping waste from the small quantity sites to the larger treatment sites was estimated by adjusting the number of miles traveled to consolidate the waste against the total miles traveled for shipment of TRU waste to WIPP. The impacts of this additional mileage have been included in the results in Table 5-26.

Table 5-27 summarizes the impacts to MEIs who might be exposed to radiation because of traffic jams, lifestyles, or occupations. The discussion in Section 5.1.8.3 presents the methods used to determine the impacts presented in Table 5-27. The departure inspector was estimated to have the highest impact with a 0.8 percent chance of an LCF.

Table 5-27
Radiological Impacts to MEIs from Truck Transportation Under Action Alternative 1 (Probability of an LCF)

Individual	CH-TRU Waste	RH-TRU Waste	Total
Stuck in traffic next to shipment	2.5E-6	5.0E-6	7.5E-6
Departure Inspector	6.8E-4	7.4E-3	8.1E-3
State Vehicle Inspector	1.0E-3	1.9E-3	2.9E-3
Residing adjacent to access route	3.0E-4	7.5E-4	1.1E-3
Rest stop employee	1.5E-4	2.5E-4	4.0E-4

5.2.8.4 Radiological Impacts from Truck Transportation Accidents

Two types of analyses were conducted for SEIS-II radiological impacts from accidents. The first type of analysis determined the radiological impact from accidents during transportation from each of the 10 treatment sites to WIPP. This analysis took into account eight different severities of accidents, the number of miles from each site, and the number of shipments. The methods used were the same as those presented in Section 5.1.8.4.

The results of the analyses for route-specific accidents for the entire shipping campaign are presented in Table 5-28. The aggregate radiological impact was estimated to be 0.8 LCF.

Table 5-28
Aggregate Radiological Population Impacts from Truck Transportation Accidents Under Action Alternative 1 (LCFs)

Originating Site	CH-TRU Waste			RH-TRU Waste			TOTAL		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
Argonne National Laboratory-East	4.0E-4	---	4.0E-4	---	---	---	4.0E-4	---	4.0E-4
Hanford Site	0.3	0.2	0.5	0.06	2.0E-3	0.07	0.4	0.2	0.6
Idaho National Engineering Laboratory & Argonne National Laboratory - West	0.07	0.09	0.2	2.5E-3	5.0E-4	3.0E-3	0.07	0.09	0.2
Lawrence Livermore National Laboratory	1.5E-3	---	1.5E-3	---	---	---	1.5E-3	---	1.5E-3
Los Alamos National Laboratory	3.0E-3	1.0E-3	4.0E-3	1.5E-5	5.0E-6	2.0E-5	3.0E-3	1.0E-3	4.0E-3
Mound Plant	1.0E-3	0	1.0E-3	---	---	---	1.0E-3	---	1.0E-3
Nevada Test Site	5.0E-4	0	5.0E-4	---	---	---	5.0E-4	---	5.0E-4
Oak Ridge National Laboratory	2.5E-3	5.0E-4	3.0E-3	4.5E-3	2.5E-3	7.0E-3	7.0E-3	3.0E-3	0.01
Rocky Flats Environmental Technology Site	7.0E-3	---	7.0E-3	---	---	---	7.0E-3	---	7.0E-3
Savannah River Site	0.02	6.0E-3	0.03	---	---	---	0.02	6.0E-3	0.03
Total LCFs							**0.5**	**0.3**	**0.8**

The second type of analysis was an assessment of four conservative, bounding accident scenarios: two involving the breach of a TRUPACT-II, and two involving the breach of an RH-72B. Methods of estimating impacts from bounding case accidents are presented in Appendix E and Section 5.1.8.4. For Action Alternative 1, the potential radiological impacts from the bounding case accidents would be the same as those presented for the Proposed Action in Section 5.1.8.4. For both alternatives, TRU waste would be treated to planning-basis WAC.

5.2.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents

As with the Proposed Action, the hazardous chemical releases from a severe accident would present negligible hazard to the exposed population. Though the inventory for Action Alternative 1 is larger than that for the Proposed Action, the concentration of VOCs and metals in each TRUPACT-II or RH-72B would be the same. Hazardous chemical impacts from accidents would be the same as those presented for the Proposed Action in Table 5-10.

5.2.8.6 Transportation Impacts Associated with Rail Shipment

This section presents a summary of potential impacts due to transportation by both regular and dedicated rail service. Rail service would be used to the fullest extent practical (called maximum rail), whereas truck transportation would be used only for the two sites with no rail service, LANL and NTS. SEIS-II rail impacts were determined by adjusting the SEIS-II impacts from truck transportation presented earlier in this section. Overall, these adjustments were based on the similarities and differences between the two transportation modes based on models presented in RADTRAN (Neuhauser and Kanipe 1992) and truck and rail accident statistics (Saricks and Kviteck 1994). The similarities and differences are presented in Appendix E. Some key differences are noted below:

- Overall, rail cars move slower than trucks. When vehicles move slower, those individuals living or traveling along a route are exposed for longer periods of time.

- Six TRUPACT-IIs would be put on each rail car instead of the three transported per truck. Two RH-72Bs would be put on each rail car instead of the one transported per truck.

- Each train can include many rail cars. For the purpose of SEIS-II analyses, it was assumed that a train transporting TRU waste would include three rail cars loaded with TRUPACT-IIs or RH-72Bs. For dedicated rail service, it was assumed that each train would only have the three rail cars. For regular rail service, it was assumed that the three rail cars of TRU waste would be included in a train of 70 rail cars (the average number of cars in regular rail service trains).

- When a train stops at a rail yard, there typically are other rail cars there. These other rail cars provide shielding for the potential radiation coming from TRU waste packaging.

- While many people would share a roadway with a truck transporting TRU waste, very few people would travel along a rail route at the same time as a train transporting TRU waste.

These differences result in the following adjustments to truck transportation results:

- The slower average train speed would increase the radiation dose to individuals living along rail routes by 1.5 times over that for individuals living along truck routes.

- When a shipment stops, the individual dose would be one-tenth of the dose to individuals near a stopped truck. This difference is due to the shielding provided by the other rail cars when the shipment stops in a railyard.

- When these two factors are considered together, accident-free radiological impacts are greatly reduced for rail transportation compared to truck transportation. Accident-free radiological impacts from truck or rail transportation were dominated by radiation doses received at stops.

Rail accident statistics typically include the number of trains and the number of accidents and fatalities. The statistics do not typically include information concerning the number of fatalities per rail car. For the purpose of SEIS-II analyses, it is important to understand the number of accidents and fatalities per rail car, because a commercial train has the same probability of being in an accident whether it contains rail cars with TRU waste or not. The standard method of calculating the number of accidents and fatalities per commercial train is to divide the average number of rail cars per train by 70. Therefore, when a train of 70 cars is in an accident that results in one death, that fatality would count as 1/70th of a fatality for each rail car. If that train included three rail cars of TRU waste, 3/70ths of that fatality would be apportioned to rail cars of TRU waste.

There are no statistics on the average number of cars in dedicated trains; as a result, making such adjustments becomes more difficult. The assumption for SEIS-II is that each dedicated train would only have three rail cars carrying TRU waste. Should a dedicated train be involved in an accident that results in a fatality, that fatality would be apportioned as 1/3 a fatality for each rail car. This number could be changed a great deal, though, by increasing the number of rail cars per train.

In essence use of regular rail transportation would add one train to the rail system for every 70 rail cars of TRU waste while use of dedicated trains would add more than 23 trains to the rail system for every 70 rail cars of TRU waste. Thus the number of rail accidents using dedicated trains would be 23 times that expected for regular rail service.

Table 5-29 presents the impacts of transportation by regular and dedicated rail for Action Alternative 1. The impacts presented in this table represent three rail cars of TRU waste in either regular or dedicated rail transport. Further details on the estimation of rail impacts can be found in Appendix E.

Table 5-29
Rail (Regular and Dedicated) Transportation Impacts Under Action Alternative 1

Aggregate Traffic-Related Fatalities	
Regular Rail	9
Dedicated Rail	216
Aggregate Accident-Free Impacts (LCFs)	
CH-TRU Waste	
Occupational	0.02
Nonoccupational	
Stops	0.3
Sharing Route	1.6E-3
Along Route	0.09
Nonoccupational Total	0.4
RH-TRU Waste	
Occupational	0.01
Nonoccupational	
Stops	0.8
Sharing Route	3.8E-3
Along Route	0.2
Nonoccupational Total	1.0
Total CH-TRU and RH-TRU Waste	
Occupational	0.03
Nonoccupational	
Stops	1.1
Sharing Route	5.4E-3
Along Route	0.3
Nonoccupational Total	1.4
Aggregate Radiological Impacts from Rail Transportation Accidents (LCFs)	
CH-TRU Waste	0.7
RH-TRU Waste	0.08
Total CH-TRU and RH-TRU Waste	0.8

Radiological impacts from rail transportation accidents were estimated relative to impacts presented for truck transportation accidents. As described under Action Alternative 1, two types of analyses were conducted for SEIS-II radiological impacts due to accidents. The first estimated impacts over the entire shipping campaign and the second estimated impacts from four bounding case accidents.

For the first analysis, the impacts were estimated based on the number of shipments, the accident frequency for each route, and the eight accident severity categories presented in RADTRAN. Because the number of miles traveled are similar between truck and rail and the rail car accident frequency is less than the truck accident frequency, it was conservatively estimated that the aggregate radiological impacts for rail transportation would be the same as those reported for truck transportation.

The estimation of radiological impacts for bounding truck accidents was done assuming that only one TRUPACT-II or RH-72B would fail in an impact event. The basis for this assumption was Fischer et al. (1987), which states that impact with a hard target, such as a bridge abutment, could potentially breach one container per shipment. To breach the container, though, it must strike a hard target head on.

For rail shipments, it was assumed that each train would include three rail cars of TRU waste. Each rail car would carry six TRUPACT-IIs or two RH-72Bs. It was also assumed that for the bounding case accidents two TRUPACT-IIs or RH-72Bs could potentially be breached. The accidents would be derailments where two rail cars would strike bridge abutments on either side of

the tracks. Although other TRUPACT-IIs or RH-72B casks might experience impact forces, it was assumed that the forces would be insufficient to breach the containers. The estimated population doses would be dominated by inhalation contributions (initial or from resuspension). The impacts are presented below:

- For the accident with the conservative inventory in two breached TRUPACT-IIs, the total population dose would result in 32 LCFs in the exposed population. The estimated maximum individual dose would result in a 12 percent chance of a cancer fatality.

- For the accident with a conservative inventory in two breached RH-72Bs, the total population dose would result in 32 LCFs in the exposure population. The estimated maximum individual dose would result in a 12 percent chance of a cancer fatality.

- For the accident with average concentrations of radionuclides in two breached TRUPACT-IIs, approximately 6 LCFs in the exposed population would be expected. The estimated maximum individual dose would result in a 8 percent chance of a cancer fatality.

- For the accident with average concentrations of radionuclides in two breached RH-72Bs, the total population dose would result in an expectation of 0.08 LCF in the population. The estimated maximum individual dose would result in a 0.14 percent chance of a cancer fatality.

As in the case for truck transportation, there would be negligible impacts from hazardous chemical releases in a rail transportation severe accident.

5.2.9 Human Health Impacts from Waste Treatment, Storage, and Disposal Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment, lag storage, and waste disposal operations under Action Alternative 1. The methods and assumptions used were similar to those used for the Proposed Action and described in Section 5.1.9, except that the inventory to be disposed of would include the Total Inventory (except for the PCB-commingled waste). Impacts from waste treatment were adjusted from those presented in the Draft WM PEIS, and a description of this adjustment is provided in Appendix B. Action Alternative 1 also includes analysis of potential impacts from TRU waste in lag storage (waste that would be treated and stored awaiting shipment to WIPP for disposal). Lag storage impact estimates were made assuming the waste would be at the lag storage site for the same lifetime exposure periods as for WIPP disposal operations: 70 years for an MEI, 35 years for the surrounding population, and 35 years for noninvolved and involved workers. The shorter exposure time for the population reflects population turnover resulting from deaths, immigration, and emigration. Appendix F provides additional information on the methods used to determine the impacts from lag storage and WIPP disposal operations.

5.2.9.1 Public

Impacts to the populations and to the MEIs under Action Alternative 1 are presented in this section; results are presented in Table 5-30. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at multiple DOE sites but not WIPP, while disposal operations would take place only at WIPP. Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites, all lag storage sites, and at WIPP. The impacts to the MEIs from waste treatment

Table 5-30
Lifetime Human Health Impacts to the Public from Waste Treatment, Lag Storage, and WIPP Disposal Operations Under Action Alternative 1

Category	Waste Treatment Impacts[a]		Lag Storage Impacts[b]		WIPP Disposal Operations Impacts	
	Radiological (LCF)[c]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[c]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[c]	Hazardous Chemical (Cancer Incidence)[d]
MEI[e, f]						
Basic Inventory						
CH-TRU Waste	8E-9 (L)	4E-12	2E-6 (O)	6E-8 (L)	3E-7	1E-8
RH-TRU Waste	9E-11 (H)	8E-12 (O)	1E-9 (O)	5E-8 (O)	8E-10	2E-9
Total Waste	8E-9 (L)	8E-12 (O)	2E-6 (O)	6E-8 (L)	3E-7	1E-8
Total Inventory						
CH-TRU Waste	1E-8 (L)	5E-12	2E-6 (O)	1E-7 (L)	5E-7	2E-8
RH-TRU Waste	9E-11 (H)	8E-12 (O)	2E-9 (O)	7E-8 (O)	7E-10	2E-9
Total Waste	1E-8 (L)	8E-12 (O)	2E-6 (O)	1E-7 (L)	5E-7	2E-8
Population[e]						
Basic Inventory						
CH-TRU Waste	2E-4	2E-7	1E-2	2E-3	2E-4	2E-5
RH-TRU Waste	5E-6	2E-7	3E-5	4E-4	1E-6	9E-7
Total Waste	2E-4	4E-7	1E-2	2E-3	2E-4	2E-5
Total Inventory						
CH-TRU Waste	2E-4	2E-7	1E-2	2E-3	3E-4	2E-5
RH-TRU Waste	5E-6	2E-7	4E-5	5E-4	9E-7	9E-7
Total Waste	2E-4	4E-7	1E-2	3E-3	3E-4	2E-5

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] These sites would have the maximum impacts.
[c] The probability of an LCF occurring to the MEI, and the number of LCFs in the population.
[d] If a panel full of CH-TRU waste remained open during the entire 70-year lifetime of the MEI and VOCs were released at a constant rate, the MEI lifetime risk from the CH-TRU waste would be 5E-8.
[e] The MEI and populations evaluated for treatment, storage, and operations impacts are different.
[f] H = Hanford, L = LANL, O = ORNL

and lag storage are presented for the highest individual waste treatment sites, while the MEI from disposal operations is near the WIPP site. See Chapter 3 for additional information on where treatment and storage would occur under Action Alternative 1.

Waste Treatment

No LCFs would be expected in the total population around the waste treatment sites (2×10^{-4} LCFs); no cancer incidence (4×10^{-7} cancers) would be expected in the total population from hazardous chemical exposure. The MEI would be at LANL for radiological impacts (1×10^{-6} percent chance of an LCF), and at ORNL for hazardous chemical impacts (8×10^{-10} percent chance of a cancer incidence). No noncarcinogenic health effects would occur because the maximum HI for the MEI would be 4×10^{-10}, and no health effect is predicted unless the HI is 1 or higher.

Lag Storage

No LCFs would be expected in the total population around the lag storage sites (1×10^{-2} LCFs); no cancer incidence (3×10^{-3} cancers) would be expected in the total population from hazardous chemical exposure. The MEI would be at ORNL for radiological impacts (2×10^{-4} percent chance of an LCF), and at LANL for hazardous chemical impacts (1×10^{-5} percent chance of a cancer incidence). No noncarcinogenic health effects would occur; the maximum HI for the MEI would be 6×10^{-4}. No health effect is predicted unless the HI is 1 or higher.

WIPP Disposal Operations

No LCFs would be expected in the population around WIPP from radiation exposure (3×10^{-4} LCFs). No cancer incidence (2×10^{-5} cancers) would be expected in the population from hazardous chemical exposure.

The MEI was assumed to be located at the Land Withdrawal Area boundary, the closest point at which an individual could reside. The MEI would have a 5×10^{-5} percent chance of an LCF from radiation exposure and a 2×10^{-6} percent chance of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur; the maximum HI for the MEI was estimated to be 7×10^{-5}, and no health effect is predicted unless the HI is 1 or higher.

5.2.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under Action Alternative 1 are presented in this section; results are presented in Table 5-31. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, handling, or disposal of waste. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different noninvolved worker populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at multiple DOE sites but would not include WIPP. Disposal operations would take place only at WIPP. The impacts to the maximally exposed noninvolved worker from waste treatment and lag storage are presented for the highest individual waste treatment sites, while the

Table 5-31
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations Under Action Alternative 1

Category	Waste Treatment Impacts[a]		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)[c]
Maximally Exposed Noninvolved Worker[d,e]						
Basic Inventory						
CH-TRU Waste	7E-9 (S)	1E-11	8E-6 (O)	2E-7 (I)	2E-7	5E-8
RH-TRU Waste	3E-10 (H)	5E-11 (O)	1E-8 (O)	4E-8 (H)	2E-9	4E-9
Total Waste	7E-9 (S)	5E-11 (O)	8E-6 (O)	2E-7 (I)	2E-7	5E-8
Total Inventory						
CH-TRU Waste	8E-9 (S)	2E-11	8E-6 (O)	5E-7 (I)	4E-7	9E-8
RH-TRU Waste	3E-10 (H)	5E-11 (O)	4E-9 (O)	4E-8 (H)	2E-9	4E-10
Total Waste	8E-9 (S)	5E-11 (O)	8E-6 (O)	5E-7 (I)	4E-7	9E-8
Population[d]						
Basic Inventory						
CH-TRU Waste	2E-5	5E-8	3E-2	4E-3	2E-4	5E-5
RH-TRU Waste	2E-7	5E-8	6E-5	7E-4	2E-6	4E-6
Total Waste	2E-5	1E-7	3E-2	5E-3	2E-4	5E-5
Total Inventory						
CH-TRU Waste	2E-5	6E-8	4E-2	9E-3	4E-4	1E-4
RH-TRU Waste	2E-7	5E-8	9E-5	8E-4	2E-6	4E-7
Total Waste	2E-5	1E-7	4E-2	5E-3	4E-4	1E-4

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring to the maximally exposed noninvolved worker, and the number of LCFs in the population.
[c] If a panel full of CH-TRU waste remained open during the entire 70-year lifetime of the MEI and VOCs were released at a constant rate, the noninvolved worker lifetime risk from the CH-TRU waste would be 5E-8.
[d] The noninvolved workers considered for treatment impacts and operations impacts are different.
[e] H = Hanford, I = INEL, L = LANL, O = ORNL, S = SRS

maximally exposed noninvolved worker from disposal operations was assumed to work at the WIPP location where emissions have the least atmospheric dispersion and thus the greatest potential impact. This location was assumed to be 200 meters (660 feet) east of the exhaust filter building. The maximum ground-level concentrations of any airborne contamination would be expected at this location.

Waste Treatment

No LCFs would be expected in the total noninvolved worker population at the waste treatment sites (2×10^{-5} LCFs); no cancer incidence (1×10^{-7} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at SRS for radiological impacts (8×10^{-7} percent chance of an LCF) and at ORNL for hazardous chemical impacts (5×10^{-9} percent chance of a cancer incidence). No noncarcinogenic health effects would occur. The maximum HI for the maximally exposed noninvolved worker would be 3×10^{-9}, and no health effect is predicted unless the HI is 1 or higher.

Lag Storage

Radiological impacts from lag storage would be somewhat greater than nonradiological impacts to noninvolved workers under Action Alternative 1. No LCFs would be expected in the total noninvolved worker population at the lag storage sites (4×10^{-2} LCFs); no cancer incidence (5×10^{-3} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at ORNL for radiological impacts (8×10^{-4} percent chance of an LCF) and at INEL for hazardous chemical impacts (5×10^{-5} percent chance of a cancer incidence). No noncarcinogenic health effects would occur; the maximum HI for any maximally exposed noninvolved worker would be 4×10^{-3}.

WIPP Disposal Operations

No LCFs would be expected in the WIPP noninvolved worker population from radiation exposure (4×10^{-4} LCFs). VOC release estimates were the same as for the public. No cancer incidence (1×10^{-4} cancers) would be expected in the noninvolved worker population from hazardous chemical exposure. All 1,095 WIPP employees were assumed to be exposed at the same level as the maximally exposed noninvolved worker.

The maximally exposed noninvolved worker would have a 4×10^{-5} percent chance of an LCF from radiation exposure, and a 9×10^{-6} percent chance of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur; the maximum HI for the maximally exposed noninvolved worker would be 6×10^{-4}.

5.2.9.3 Involved Workers

Impacts to involved workers who would handle waste during treatment, lag storage, and WIPP disposal operations under Action Alternative 1 are presented in this section. Results are presented in Table 5-32. The methods used to estimate impacts from waste treatment and WIPP disposal operations are described at the beginning of Section 5.1.9 and in Section 5.1.9.3. Additional information is presented in Appendix F. In actuality, all worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-32
Lifetime Human Health Impacts to Involved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations Under Action Alternative 1[a]

Category	Waste Treatment Impacts[b]		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)
Population					(36 workers)	(36 workers)
Basic Inventory						
CH-TRU Waste	1.4	2E-5	0.5	0.02	0.2	0.01
RH-TRU Waste	0.01	8E-6	≤0.5	≤0.02	≤0.2	1E-3
Total Waste	1.4	3E-5	≤1	≤0.04	≤0.4	0.01
Total Inventory						
CH-TRU Waste	3.1	5E-5	0.5	0.02	0.4	0.03
RH-TRU Waste	0.01	9E-6	≤0.5	≤0.02	≤0.4	1E-3
Total Waste	3.1	6E-5	≤1	≤0.04	≤0.8	0.03

[a] The involved worker populations considered for treatment impacts and operations impacts are different.
[b] Adapted from the Draft WM PEIS (DOE 1995f).

Waste Treatment

Radiological impacts to the involved worker population from waste treatment would be greater than nonradiological impacts. Up to 3.1 radiation-related LCFs could occur in the worker population while no cancer incidence (6×10^{-5} cancers) would be expected from hazardous chemical exposure. No noncarcinogenic health effects would occur. The maximum exposure index for a waste treatment worker would be 3×10^{-4}, and no health effect is predicted unless the exposure index is 1 or higher. Additional information is presented in Appendix F.

Lag Storage

Radiological impacts to the involved worker population from lag storage would be less than or equal to 1 LCF, and hazardous chemical impacts would be less than 0.04 cancers. No noncarcinogenic health effects would occur. Involved worker lag storage impacts would be larger from CH-TRU waste storage operations than from RH-TRU waste storage operations because of remote RH-TRU waste handling and greater administrative controls for RH-TRU waste. Therefore, no specific RH-TRU waste lag storage impact estimates were made. Impacts were assumed to be less than or equal to those for CH-TRU waste.

The impacts from CH-TRU waste would be from the external radiation dose received during waste container handling. Potential radiological impacts from inhalation of radioactive gases released from waste containers would be negligible. Involved worker impacts from lag storage were calculated by assuming waste handlers would spend 2 hours every workday at 1 meter (3.3 feet) from the CH-TRU waste containers. The workers were assumed to be exposed over a 35-year career. Container dose rates were decay-corrected over the 35 years, and all sites were assumed to have 20 percent of the Total Inventory contained in storage at all times.

WIPP Disposal Operations

Radiological impacts to the involved worker population from disposal operations at WIPP would be less than 0.8 LCF. WIPP involved worker radiological impact estimates were made assuming each involved worker who handled CH-TRU waste would receive a radiation dose (TEDE) of 1 rem per year. Impacts to involved workers from RH-TRU waste handling were assumed to be the same or less than those from CH-TRU waste handling. This assumption is conservative

because RH-TRU waste is typically handled using remote-handling equipment, workers are usually protected by radiation shielding, and stricter administrative procedures are used. The impact from handling RH-TRU waste, therefore, would probably be less than the impact from handling CH-TRU waste.

Hazardous chemical impacts to the involved worker population would be less than 0.03 cancers, and no noncarcinogenic health effects would occur. Involved worker exposures to VOCs were evaluated in the Waste Handling Building and underground, as was done for the Proposed Action. The potential carcinogenic impacts would be greatest for the individual underground worker. Noncarcinogenic health effects were also estimated. The same methods and assumptions were used as for the Proposed Action (Section 5.1.9.3). Workers were assumed to be exposed for 35 years. The results were the same as those presented for the Proposed Action.

5.2.10 Facility Accidents

Impacts under Action Alternative 1 would be the same as those for the Proposed Action for treatment and WIPP disposal accidents. However, there would be lag storage of CH-TRU and RH-TRU waste under Action Alternative 1; therefore, impacts resulting from storage accidents are discussed for the six sites under evaluation (Hanford, LANL, INEL, SRS, RFETS, and ORNL). Impacts of storage accidents were evaluated for storage at these six sites because they would store about 99 percent of the CH-TRU and RH-TRU waste under Action Alternative 1.

5.2.10.1 Waste Treatment Accidents

The impacts from waste treatment accidents under Action Alternative 1 would be the same as those under the Proposed Action (see Section 5.1.10.1).

5.2.10.2 Waste Storage Accidents

Three potential waste storage accidents were evaluated for Action Alternative 1; they're shown in Table 5-33. Results are presented only for accidents involving CH-TRU waste; these results would be greater than results for similar accidents involving RH-TRU waste. Lower transuranic radionuclide activity in RH-TRU waste (lower PE-Ci levels, see Table G-23 and Table G-24), lower RH-TRU waste volume, more robust waste containers for RH-TRU waste, and presumably more robust construction of RH-TRU waste storage facilities (thick concrete walls for external radiation shielding) would all combine to limit potential impacts from RH-TRU waste accidents. Waste would be consolidated at 10 sites for lag storage under Action Alternative 1.

Table 5-33
Storage Accident Scenarios Evaluated for Action Alternative 1

Accident Scenarios	Annual Occurrence Frequency	Description
Drum Puncture, Drop, and Lid Failure (Accident Scenario S1)	1E-2 to 1E-4	A forklift strikes and punctures a drum on a lower level of a stack in the storage facility. The stack is destabilized and two drums fall to the ground and lose their lids upon impact.
Drum Fire (Accident Scenario S2)	1E-4 to 1E-6	A fire spontaneously erupts in a waste drum.
Earthquake (Accident Scenario S3)	1E-5 or less	A beyond-design-basis earthquake occurs, causing the storage building to collapse.

Storage accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a beyond-design-basis natural disaster accident. CH-TRU waste involved in the accidents were assumed to have the highest levels of radionuclides (80 PE-Ci per drum) permitted by the planning-basis WAC, conservative concentrations of VOCs (based on CH-TRU waste sampling and planning-basis WAC limits), and conservative concentrations of hazardous metals. Additional details on the accident analyses are presented in Appendix G.

Estimated radiological impacts are presented as the number of LCFs in the exposed population and as the percent chance of an LCF occurring in MEIs (tables present the probability of an LCF for MEIs). Carcinogenic and noncarcinogenic impacts from hazardous chemicals, both VOCs and hazardous metals, were estimated. Carcinogenic impacts are presented as the number of cancers in the exposed population and the percent chance of cancer for MEIs. Noncarcinogenic impacts from exposure to VOCs and hazardous metals were estimated by two different methods for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2, respectively): IDLH-equivalent ratios and ERPG ratios. Only IDLH-equivalent ratios were calculated for the earthquake scenario (Accident Scenario S3). The potential noncarcinogenic impacts identified by ERPG ratios would be of minor importance during such a catastrophic event and its consequent site-operations upheaval.

In general, potential radiological impacts would be higher than hazardous chemical impacts, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-34.

Table 5-34
Radiological Impacts Storage Accidents for Action Alternative 1[a]

Accident Scenarios	Population (number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Drum Puncture and Lid Failure (Accident Scenario S1)	Maximum: 5E-4 (RFETS)	Maximum: 3E-7 (ORNL)	Maximum: 4E-7 (Hanford)
Drum Fire (Accident Scenario S2)	Maximum: 2E-3 (RFETS, ORNL)	Maximum: 1E-6 (ORNL)	Maximum: 2E-6 (Hanford, LANL, ORNL)
Earthquake (Accident Scenario S3)	Hanford: 200 INEL: 6 LANL: 50 RFETS: 300 ORNL: 6 SRS: 30	Hanford: 0.06 INEL: 3E-3 LANL: 0.07 RFETS: 0.02 ORNL: 4E-3 SRS: 2E-3	Hanford: 0.7 INEL: 0.05 LANL: 0.2 RFETS: 0.09 ORNL: 6E-3 SRS: 0.2

[a] The site with the greatest impact is shown in parentheses.

Public

Population impacts from storage accidents were estimated for the exposed populations around the six major treatment sites. Potential impacts to the population and MEIs at the six sites vary over a wide range because of different population distributions, distances to the MEIs, and atmospheric dispersion factors among the sites. No LCFs would be expected in the exposed population from drum puncture or drum fire accidents (Accident Scenarios S1 and S2, respectively), but LCFs were estimated to occur from the earthquake accident (Accident Scenario S3) at all sites. The number of

LCFs ranged from 6 (at ORNL and INEL) to 300 (at RFETS). The radiological impacts were estimated to be the highest to the MEI at ORNL for the drum puncture and drum fire accidents (Accident Scenarios S1 and S2). Impacts from the earthquake accident (Accident Scenario S3) were estimated to range from a 0.2 to 7 percent chance of an LCF to the MEI.

Carcinogenic impacts from VOCs would be one to six orders of magnitude greater than impacts from hazardous metals for the drum puncture and earthquake scenarios (Accident Scenarios S1 and S3, respectively). Hazardous metals account for all carcinogenic impacts from the drum fire accident (Accident Scenario S2) because VOCs would be consumed by the fire. No cancer was estimated to occur in the exposed population from the hazardous chemical releases of any accident. The maximum percent chance of cancer to an MEI would be 9×10^{-8} for both the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2, respectively). The maximum percent chance of cancer to the MEI would be 4×10^{-5} for the earthquake accident (Accident Scenario S3). No noncarcinogenic impacts would be expected for any of the three accidents evaluated.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest impact outside of the waste storage facility. The impacts to the noninvolved worker would vary over a narrow range across the six sites evaluated. The range was narrow because of the uniform release height and close distances considered for all noninvolved workers.

Radiological impacts to the maximally exposed noninvolved worker would result in a 4×10^{-5} percent chance of an LCF (at Hanford) from events of the drum puncture scenario (Accident Scenario S1), a 2×10^{-4} percent chance of an LCF (at Hanford, LANL, or ORNL) from the events of the drum fire scenario (Accident Scenario S2), and up to a 70 percent chance of an LCF (at Hanford) from the beyond-design-basis earthquake (Accident Scenario S3).

Hazardous chemical impacts would be relatively minor in comparison to the radiological impacts. The maximum percent chance of cancer to the maximally exposed noninvolved worker from VOC and heavy metal intakes would be 1×10^{-7} for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2, respectively). The corresponding impact for the earthquake scenario (Accident Scenario S3) would be a 3×10^{-4} percent chance of cancer. A Hanford noninvolved worker could experience a minor noncarcinogenic health effect from drum puncture releases (Accident Scenario S1) of 1,1,2,2-tetrachloroethane.

Maximally Exposed Involved Worker

The involved worker would be the individual most seriously impacted by the events of the drum puncture and earthquake scenarios (Accident Scenarios S1 and S3, respectively) because of close proximity to the accidents. Impacts were quantitatively estimated for the drum puncture scenario (Accident Scenario S1). The maximally exposed involved worker could have a 7 percent chance of an LCF as a result of the radionuclide intake from this accident. The analysis assumed the instantaneous radioactive material releases from the three containers, expanding in a uniform hemisphere of 3 meters (9.9 feet) in diameter. The worker was assumed to inhale approximately five breaths of this air prior to exiting the facility.

The involved worker could have a 5×10^{-5} percent chance of contracting cancer from estimated hazardous chemical intakes due to the events of the drum puncture scenario (Accident Scenario S1). Noncarcinogenic impacts could be irreversible but would not be life-threatening under the assumed exposure assumptions. These impacts could result from the potential releases of 1,1,2,2-tetrachloroethane, lead, or mercury.

Impacts from the drum fire scenario (Accident Scenario S2) would be serious if the worker happened to be adjacent to the drum when the fire began. However, a worker's actions are not required to initiate the accident; therefore the probability of exposure of a worker adjacent to the fire is small. The smoke being released from the drum would alert workers to the incident, and it can be reasonably assumed that workers would avoid exposure to the smoke.

Catastrophic destruction of the storage facility during an earthquake (Accident Scenario S3) could result in death or serious injury to the maximally exposed involved worker due to a falling ceiling or other debris and radiation doses.

5.2.10.3 WIPP Disposal Accidents

The impacts from accidents during WIPP disposal operations under Action Alternative 1 would be the same as those under the Proposed Action (see Section 5.1.10.3).

5.2.11 Industrial Safety

A total of four fatalities from industrial accidents would occur under Action Alternative 1 during waste treatment at all treatment sites. This result was determined by adjusting the physical-hazard fatality estimate of the Draft WM PEIS.

Under Action Alternative 1, the WIPP operational activities would be essentially the same as those conducted under the Proposed Action but would last approximately 160 years rather than 35 years. Decommissioning activities would be the same as under the Proposed Action. Estimated industrial safety impacts to workers under Action Alternative 1 are presented in Table 5-35. Oversight and inspections by the MSHA and adherence to OSHA regulations would probably reduce actual occurrences below these estimated values.

Table 5-35
Industrial Safety Impacts from Operations and Decommissioning Under Action Alternative 1

Years	Injuries/Illnesses			Fatalities		
	Construction	Operations	Total	Construction	Operations	Total
Operations 1998-2158	99	5,600	5,699	0.2	5.6	5.8
Decommissioning 2159-2168	187	96	283	0.3	0.1	0.4
Total	286	5,696	5,982	0.5	5.7	6.2

5.2.12 Long-Term Post-Closure Performance

Analyses of the long-term impacts from WIPP under Action Alternative 1 were conducted using the same suite of computer models as for the Proposed Action. Details on the data used for flow and transport are provided in Appendix H. The radionuclide and hazardous metals inventories were increased for Action Alternative 1 to account for the increased inventory destined for WIPP. A total of 7.2 x 10^6 Ci of CH-TRU waste and 5.1 x 10^6 Ci of RH-TRU waste was included for this alternative. Detailed information on the radionuclide and hazardous material inventories are provided in Appendix A. Also, the repository size was adjusted from 10 panels to 68 panels. The

material properties outside the repository were not changed from the comparable cases analyzed for the Proposed Action.

The four cases below were analyzed for Action Alternative 1. The cases considered the following conditions:

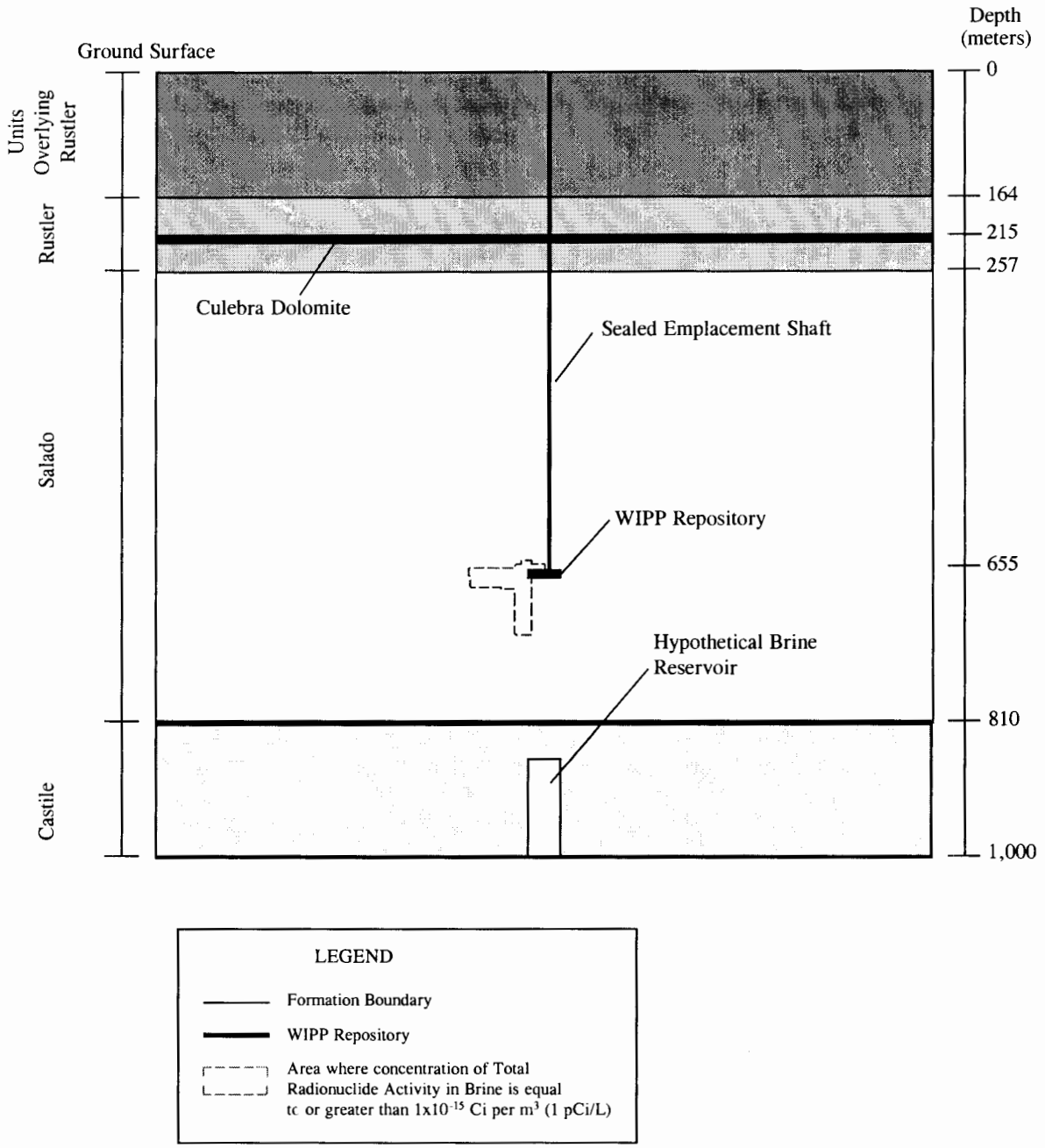
- Case 6 considered undisturbed repository conditions. Median parameter values were used for all input variables where probability distributions have been defined.
- Case 7 considered disturbed conditions resulting from an exploratory borehole that penetrates the repository and intercepts a brine pocket in the Castile Formation. Median parameters values were used.
- Case 8 considered undisturbed repository performance with 75th percentile parameter values for all input variables where probability distributions have been defined.
- Case 9 considered disturbed conditions resulting from an exploratory borehole that penetrates the repository and intercepts a brine pocket in the Castile Formation. Seventy-fifth percentile parameter values were used.

As discussed in the following sections, the results of this analysis indicate that there is remarkably little difference between the amounts of radionuclide and hazardous chemical releases from the repository when the analysis is conducted using both median and 75th percentile values. The results using the 75th percentile values provide slightly greater impacts in each and are presented in the figures in this chapter. For each alternative, the analysis of both median and 75th percentile values was conducted in order to demonstrate that the results are conservative.

5.2.12.1 Impacts of the Undisturbed Repository Conditions

The extent of radionuclide and hazardous metal (predominately lead) migration for undisturbed conditions at 10,000 years after closure for Case 8 (using 75th percentile parameters) is presented in Figure 5-3. Case 8 resulted in more extensive migration than Case 6.

For undisturbed conditions, results from Action Alternative 1 simulations showed about the same amount of downward migration and greater lateral and upward migration of radionuclides and hazardous metals as the Proposed Action. Total radionuclide concentrations of 1 pCi per liter and total hazardous metals concentrations of 1 part per billion would extend about 60 meters (200 feet) below the repository, 15 meters (50 feet) above the repository, and about 3,600 meters (11,800 feet) laterally. For Cases 6 and 8 (the undisturbed repository cases) during the first 10,000 years, the following were found: (1) no radioactive or hazardous metal waste would be released to the Culebra Dolomite, and (2) no radionuclide concentrations greater than 1 pCi per liter or hazardous metal concentrations greater than 1 part per billion would be found beyond the 5-kilometer (3-mile) subsurface lateral boundary. Therefore, the estimated human impact was zero for the undisturbed repository cases for Action Alternative 1. Detailed data for these model runs are provided in Appendix H.



Note: Results show the area of concentration extending 60 meters (200 feet) below the repository, 15 meters (50 feet) above the repository, and 3,600 meters (11,800 feet) laterally from the edge of the repository.

Figure 5-3
Extent of Radionuclide Migration at 10,000 years with Undisturbed Conditions (Case 8)

5.2.12.2 Impacts of Drilling into the Repository

The impacts to "intruders" from drilling into an undisturbed repository (Case 7 and Case 9) were evaluated, for a drilling crew member and a well-site geologist. Due to the repository loading design under Action Alternative 1, one waste panel would hold only CH-TRU waste, 52 waste panels would hold only RH-TRU waste, and the remaining 16 panels would have a mixture of RH-TRU and CH-TRU waste. The estimated radionuclide releases to the ground surface from a drilling intrusion for Cases 7 and 9 would be 6.5, 0.4, and 6.8 Ci, respectively, for panels containing only CH-TRU waste, only RH-TRU waste, and both CH-TRU and RH-TRU waste. The releases would be primarily from Pu-238, Pu-239, and Am-241. Hazardous metal releases would be 4.8, 17.6, and 18.1 kilograms, respectively, for panels containing only CH-TRU waste, only RH-TRU waste, and both CH-TRU and RH-TRU waste for Cases 7 and 9. The primary metals released would be lead and mercury. Detailed results of these analyses are provided in Appendix H.

Exposure assumptions were the same as for the corresponding cases under the Proposed Action. The radiological impacts to a drilling crew member for Case 7 and Case 9 would be 3×10^{-2}, 3×10^{-2}, and 9×10^{-3} percent chance of an LCF, respectively, for CH-TRU panels, panels with both CH-TRU and RH-TRU waste, and RH-TRU waste panels. Ninety percent of the impact would be due to the inadvertent ingestion of drill cuttings and 10 percent would be due to external radiation dose. The radionuclide with the greatest impact contribution was americium-241. The impacts for Case 7 and Case 9 are the same because the intrusion would occur before any substantial transport would occur.

The radiological impact to a well site geologist for Case 7 and Case 9 would be a 4×10^{-5} percent chance of an LCF, with about 99 percent of the impact attributable to RH-TRU waste. The only pathway considered was external dose, and Sr-90 and Cs-137 were the major radionuclides contributing to the impact. The impacts for Case 7 and Case 9 are the same because the intrusion would occur before any substantial transport would occur.

5.2.12.3 Impacts of Drilling Intrusion into a Pressurized Brine Reservoir

In this scenario, it was assumed that a deep drilling intrusion would introduce a high permeability (relative to the permeability of the intact salt) groundwater pathway from the repository to the near-surface Culebra Dolomite. Contaminants could migrate up the intrusion borehole and then move laterally through the Culebra Dolomite.

The extent of radionuclide and hazardous metal (predominately lead) migration for disturbed conditions at 10,000 years after closure for Case 9 (using 75th percentile parameters) was very similar to results simulated for Case 4, shown in Figure 5-2. At 10,000 years post-closure, migration within the borehole and outward into the surrounding saltbeds would extend upward about 20 meters (66 feet) above the repository. Radionuclide and metals would also migrate downward in the borehole and into surrounding rocks into the Castile Formation and into the brine reservoir. As in the Proposed Action, this would occur after the initial pressure in the brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole over the 10,000-year simulation. Predicted brine pressures and other modeling details associated with this simulation are provided in Appendix H.

There would be no radionuclide or hazardous metal releases into the Culebra within 10,000 years of repository closure for the deep drilling scenario under Action Alternative 1. Therefore, there would be no impact to the cattle rancher described in the Proposed Action.

5.2.12.4 Impacts of Potash Mining

Results for Action Alternative 1 indicated that radionuclide and hazardous chemical releases from the repository would not reach the Culebra Dolomite for undisturbed and disturbed (borehole intrusion into the repository and a pressurized brine reservoir) conditions. Thus, the impacts of potash mining on long-term performance, as suggested in 40 CFR Part 194 and described in Section 5.1.12.4, were not evaluated.

5.3 IMPACTS OF ACTION ALTERNATIVE 2

This section describes the environmental impacts associated with the implementation of the subalternatives of Action Alternative 2. Under each subalternative, WIPP would accept the Basic Inventory and the Additional Inventory including PCB-commingled TRU waste. All TRU waste would be thermally treated to meet Land Disposal Restrictions (LDR). SEIS-II analyzed three different consolidation and treatment subalternatives, Action Alternatives 2A, 2B and 2C. Action Alternative 2C includes treatment of all CH-TRU waste at WIPP.[1] Each subalternative is described in Section 3.2.3.

The total consolidated, pretreatment volume of waste to be treated under this alternative would be 313,000 cubic meters (11 million cubic feet) (see Tables 3-4 through 3-9). The type, size, and number of treatment facilities needed under this alternative would be comparable to those assessed in the thermal treatment alternatives of the Draft WM PEIS. Treatment under each subalternative would continue for 35 years. The waste would be stored at the treatment facilities until disposal (this storage is called lag storage). The WIPP operational time frame under this alternative would extend to the year 2148 (150 years).

5.3.1 Land Use Management

Land use impacts at the treatment sites for each of the Action Alternative 2 subalternatives would be similar to those under the Proposed Action discussed in Section 5.1.1. Additional waste would be treated under this alternative, but the treatment time period would be extended to 35 years. Though the SEIS-II Action Alternative 2 subalternatives propose treating TRU waste at various DOE locations, in no case would the treatment facilities require more than 1 percent of the available land at those DOE locations. The Department would have a great deal of flexibility when determining the locations of such facilities (DOE 1995f). The Department would be able to minimize impacts to on-site land use and would be able to avoid conflicts with off-site land use plans. It also would be able to avoid sensitive or inappropriate land areas (including wetlands, flood plains, cultural resource areas, and the habitats of endangered and threatened species) (DOE 1995f). Before treatment facilities would be constructed, further NEPA review would be undertaken at a site-wide or project-specific level.

Land use impacts during disposal operations at WIPP under Action Alternatives 2A, 2B, and 2C would be similar to those under the Proposed Action, discussed in Section 5.1.1. A difference from the Proposed Action would occur during decommissioning and closure, when approximately 324 hectares (800 acres) would be affected due to an increased underground waste disposal area. Like the Proposed Action, the rest of the Land Withdrawal Area would be available to the public for nonintrusive surface activities following decommissioning and closure.

[1] The analysis of Action Alternative 2C presents impacts based on the programmatic analyses in the Draft WM PEIS. If the Department decides, based on the WM PEIS analyses, to centralize treatment at WIPP, the Department would prepare further project-specific NEPA review for any proposed treatment facility. Such review would be tiered from SEIS-II.

5.3.2 Air Quality

For Action Alternative 2A, the levels of criteria pollutants exceeding 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be those for CO at RFETS (24 percent) and PM_{10} at INEL (10 percent). Under Action Alternative 2B, the levels of criteria pollutants exceeding 10 percent would be PM_{10} at INEL (10 percent), and under Action Alternative 2C the levels of criteria pollutants exceeding 10 percent would be PM_{10} (25 percent) and SO_2 (12 percent) at WIPP (DOE 1995f) (see Appendix C for additional detail.) Minor increases in PM_{10} levels may occur during construction.

RFETS, LLNL, and ANL-E are in nonattainment areas for some of the pollutants. In those areas where air pollution standards are not met (nonattainment areas), activities that introduce new sources of emissions are regulated under the General Conformity Rule. In areas where air pollution standards are met (attainment areas), regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources that will result in emissions equal to or greater than the limits set by pertinent regulations.

Of hazardous or toxic air pollutant releases, only radionuclide releases would exceed 10 percent of the applicable regulatory standard. For Action Alternative 2A, treatment-related releases could reach 134 percent of the regulatory standard at RFETS and 48 percent of the standard at SRS. For Action Alternative 2B, treatment-related releases could reach 48 percent of the regulatory standard at SRS and 10 percent at INEL. Under Action Alternative 2C, releases could reach 319 percent of the regulatory standard at WIPP. Postulated waste treatment-related releases above the regulatory standard would require mitigation measures, such as HEPA filtration, to ensure they remained below the allowable limit.

The potential air quality impacts from the operation of WIPP for disposal under Action Alternatives 2A, 2B, and 2C would be the same as those anticipated under the Proposed Action. Although the increased waste disposal volume at WIPP would increase the duration of disposal activities, there would be no substantial difference in the rate of pollutant emissions on either an annual or a short-term basis.

Potential air quality impacts due to the decommissioning of WIPP under Action Alternative 2 would be similar to those under the Proposed Action. Construction of the berm and permanent markers and other decommissioning activities would last longer than under the Proposed Action and other alternatives, but would probably produce negligible increases in annual pollutant emissions compared to the other alternatives.

5.3.3 Biological Resources

The biological impacts at the treatment sites (including WIPP) under Action Alternatives 2A, 2B, and 2C would be the same as those for the Proposed Action. Though additional waste would be treated using a different treatment method, the size, type, and number of the treatment facilities would be comparable to those assessed in the Draft WM PEIS, which determined that construction and operation of the treatment facilities should not affect populations of nonsensitive plant and animal species. Also, terrestrial wildlife species probably would not be affected by airborne emissions nor by spills into aquatic environments due to traffic accidents (DOE 1995f). Threatened and endangered species may be present at all of the proposed treatment sites; however, impacts to these species would depend on the actual location of the facility at a particular site. Site selection would be conducted following appropriate Endangered Species Act consultation and site-wide or project-level NEPA review during which such impacts would be assessed and

mitigated, if necessary. The critical habitats of species listed by the state and federal governments as endangered, threatened or candidates would be avoided.

Federally listed, threatened and endangered, and state-listed species occur in Eddy County and potentially at the WIPP, although DOE has not observed threatened, endangered, or proposed species or critical habitats at the WIPP site during surveys conducted for recent biennial environmental compliance reports. DOE is conducting a survey to update the list of species at the site and will consult with these agencies once the survey is completed.

At WIPP, potential impacts on biological resources for disposal operations would be similar to those under the Proposed Action, described in Section 5.1.3. The increased underground waste disposal area, though, would lead to greater impacts during closure and post-closure activities. Approximately 324 hectares (800 acres) of aboveground area would be affected by decommissioning, salt pile reclamation, and closure construction of berms and permanent markers. These activities would disturb avian and small mammal habitat within and near the area. These disturbed areas would be attractive as habitat after natural vegetation recolonizes.

5.3.4 Cultural Resources

The impacts to cultural resources at the treatment sites under Action Alternatives 2A, 2B, and 2C would be the same as those for the Proposed Action. Construction and operation of treatment facilities (including that proposed for WIPP under Action Alternative 2C) could adversely affect cultural resources, but site-level cultural resource surveys would be conducted, and protection measures established, where necessary, when specific facility construction locations are proposed. These surveys would be part of site-wide or project-level NEPA reviews.

Waste shipment and disposal activities at WIPP would not have an impact on archaeological sites; however, some sites could be affected by expansion of the disposal area and closure- and decommissioning-related activities. The land that would be disturbed due to closure and decommissioning under Action Alternatives 2A, 2B, and 2C covers a substantially larger area (324 hectares [800 acres]) than that under the Proposed Action.

Since publication of SEIS-I in 1990, additional cultural resource surveys have been conducted at WIPP. Based on inventory data, and assuming environmental homogeneity and a fairly even distribution of archaeological sites, DOE estimates that the WIPP site may contain about 99 archaeological sites and 153 locations where isolated artifacts. There are no known Native American sacred sites or burials in the Land Withdrawal Area.

Measures for ensuring protection of known archaeological and historic resources, or others that may be inadvertently discovered during ground-disturbing activities, are discussed in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1996b). DOE will avoid, to the extent possible, sites found eligible for inclusion in the NRHP. Where avoidance is not possible, mitigation measures will be developed in consultation with the State Historic Preservation Office and the BLM.

5.3.5 Noise

Treatment sites would probably be located in industrial areas along high-volume highway corridors; therefore, ambient noise levels are not likely to increase substantially, although some sensitive receptors may be affected (DOE 1995f). Further assessment of these impacts was reserved until actual siting of treatment facilities is proposed in a site-wide or project-specific NEPA document. Under each Action Alternative 2 subalternative, all waste would travel to WIPP,

but only a portion of the waste would travel from or to each treatment facility; therefore, the greatest impacts due to transportation noise would be near the WIPP site.

Disposal operations at WIPP would result in noise impacts similar to those discussed for the Proposed Action in Section 5.1.5. Potential noise impacts at WIPP from truck transportation also would be similar to those under the Proposed Action (Section 5.1.5). Estimated rail noise from transportation would be similar to those under Action Alternative 1 (Section 5.2.5).

5.3.6 Water Resources and Infrastructure

The following sections discuss the water resource and infrastructure impacts of the three Action Alternative 2 subalternatives.

Action Alternative 2A

Although no off-site infrastructure impacts would be expected to occur; proposed TRU waste activities may affect on-site activities. The affected infrastructure elements analyzed were on-site transportation and the capacity of on-site water, power, and wastewater systems. For Action Alternative 2A, on-site demand for wastewater at Hanford would exceed 5 percent of current demand (7.8 percent) and at INEL, an increase in the on-site demand for power of 7 percent would occur.

Minor impacts to the on-site transportation infrastructure would be expected under Action Alternative 2A. These impacts would result from an increase in on-site employment of 9 percent at Hanford and INEL and 7 percent at LANL. Impacts to the off-site transportation infrastructure would not occur because population increases would not exceed 5 percent.

Negligible annual infrastructure impacts would be expected at WIPP under Action Alternative 2A. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

Action Alternative 2B

For Action Alternative 2B, Hanford would have an increase in on-site demand for wastewater that would exceed 5 percent of current demands (7.8 percent) and INEL would have an increase in the on-site demand for power by 7 percent.

Minor impacts to the on-site transportation infrastructure would be expected under Action Alternative 2B. These impacts would result from an increase in on-site employment of 9 percent at Hanford and 11 percent at INEL. Impacts to the off-site transportation infrastructure would not occur because population increases would not exceed 5 percent.

Negligible annual infrastructure impacts at WIPP would be expected under Action Alternative 2B for disposal operations. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

Action Alternative 2C

The greatest incremental impacts to infrastructure would occur under Action Alternative 2C due to treatment activities at the WIPP site. Expected impacts under Action Alternative 2C include INEL increasing on-site demand for power by 7 percent and WIPP increasing wastewater treatment demand by approximately 80 percent and power by 50 percent. The increase in wastewater

treatment demand at WIPP could exceed the current system capacity by approximately 60 percent. The increase in power demand at WIPP would not cause total power demand to exceed 90 percent of current capacity.

Minor impacts to the on-site transportation infrastructure would be expected under Action Alternative 2C. These impacts result from an increase in on-site employment of 6 percent at Hanford and 162 percent at WIPP. Impacts to the off-site transportation infrastructure would not be anticipated because population increases would not exceed 5 percent.

Negligible annual infrastructure impacts would be expected at WIPP under Action Alternative 2C for disposal operations. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

5.3.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for the Action Alternative 2 subalternatives are presented in the following subsections.

5.3.7.1 Life-Cycle Costs

The life-cycle costs of the three Action Alternative 2 subalternatives are presented in the following subsections.

Life-Cycle Costs for Action Alternative 2A

Table 5-36 shows the life-cycle costs under Action Alternative 2A. Waste treatment facility costs reflect construction, O&M, and D&D at the waste treatment sites, which would thermally treat waste to meet the LDRs and package the waste over a period of 35 years. In addition, Hanford, which has the largest volume, would store portions of the treated waste over a period of 150 years because of WIPP emplacement limitations. Life cycle costs include an additional $700 million to account for treatment to planning-basis WAC of waste that would be shipped for thermal treatment. The waste treatment facility life-cycle costs would be $27.7 billion (in 1994 dollars).

Life-cycle costs also include one of three options for TRU waste transportation between consolidation sites and WIPP: (1) trucks, as explained under the Proposed Action, (2) truck and rail using commercial rail as explained under Action Alternative 1, and (3) truck and rail using dedicated rail, also as explained in Action Alternative 1. Rail routes would be used to the greatest extent practicable. Under these options, transportation costs include the consolidation of waste volumes at the treatment sites and shipment via truck or rail to WIPP for emplacement. The waste transport life-cycle costs would be about $2.2 billion by truck, $723 million by regular rail, and $5.1 billion by dedicated rail.

The WIPP life-cycle costs would be $23.3 billion. The total life-cycle costs of Action Alternative 2A would be $53.2 billion ($19.4 billion when discounted) using truck, $51.6 billion ($19.2 billion when discounted) using regular rail, or $56.0 billion ($19.9 billion when discounted) using dedicated rail transportation.

Table 5-36
Life-Cycle Costs Under Action Alternative 2A
(in millions of 1994 dollars)[a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	11,000	4,400	15,400	11,500	830	12,300	27,700	15,400
Transport by Truck	531	1,100	1,600	553	104	657	2,200	370
Transport by Regular Train	311	80	391	325	7	332	723	120
Transport by Dedicated Train	2,200	562	2,800	2,300	51	2,400	5,100	860
Disposal at WIPP	10,000	2,600	12,600	10,500	233	10,700	23,300	3,700
Total Life-Cycle Cost (Truck)	21,500	8,000	29,500	22,500	1,200	23,600	53,200	19,400
Total Life-Cycle Cost (Regular Train)	21,300	7,000	28,300	22,300	1,100	23,300	51,600	19,200
Total Life-Cycle Cost (Dedicated Train)	23,200	7,500	30,700	24,200	1,100	25,300	56,000	19,900

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

Life-Cycle Cost for Action Alternative 2B

The life-cycle costs of Action Alternative 2B are presented in Table 5-37. This alternative would involve the same combined CH-TRU and RH-TRU waste volumes considered under Action Alternative 2A. However, the waste management facility costs include waste treatment at fewer TRU waste treatment sites. Again, due to WIPP emplacement limitations, the site with the largest volume (Hanford) would incur additional storage costs over the life of the project. Life-cycle costs include an additional $3.8 billion to account for treatment to planning-basis WAC of waste that would be shipped for thermal treatment. The waste treatment facility life-cycle costs at the treatment sites would be $30 billion (in 1994 dollars).

Table 5-37
Life-Cycle Costs Under Action Alternative 2B
(in millions of 1994 dollars)[a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	12,100	4,900	17,000	12,400	900	13,300	30,000	16,700
Transport by Truck	1,100	276	1,400	1,100	25	1,200	2,500	420
Transport by Regular Train	380	97	477	398	9	407	884	150
Transport by Dedicated Train	2,400	618	3,000	2,500	56	2,600	5,600	950
Disposal at WIPP	10,000	2,600	12,600	10,500	233	10,700	23,300	3,700
Total Life-Cycle Cost (Truck)	23,200	7,800	30,900	24,000	1,200	25,200	56,300	20,800
Total Life-Cycle Cost (Regular Train)	22,500	7,600	30,000	23,300	1,200	24,400	54,700	20,600
Total Life-Cycle Cost (Dedicated Train)	24,500	8,100	32,500	25,400	1,200	26,600	59,400	21,400

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

As under Action Alternative 2A, three options for waste transportation between consolidation sites and WIPP were examined: (1) trucks, as in the Proposed Action, (2) truck and rail using commercial rail as in Action Alternative 1, and (3) truck and rail using dedicated rail service, also as in Action Alternative 1. Rail routes would be used to greatest extent practicable. Transportation costs reflect consolidating the waste volumes at the treatment sites, and then shipping the waste to WIPP for emplacement. The life-cycle waste transport costs would be about $2.5 billion by truck, $884 million by regular rail, and $5.6 billion by dedicated rail.

The WIPP life-cycle costs would be $23.3 billion. The total life-cycle costs of Action Alternative 2B would be $56 billion ($20.8 billion when discounted) using truck, $54.7 billion ($20.6 billion when discounted) using regular rail, or $59.4 billion ($21.4 billion when discounted) using dedicated rail transportation.

Life-Cycle Costs for Action Alternative 2C

The life-cycle costs for Action Alternative 2C are presented in Table 5-38. The same combined CH-TRU and RH-TRU waste volumes were considered for this subalternative as were considered under the other Action Alternative 2 subalternatives. Life-cycle costs include an additional $18.5 billion to account for treatment of waste to planning-basis WAC so the waste can be shipped for thermal treatment. Waste treatment facility costs include the activities at Hanford and ORNL for RH-TRU waste and WIPP for CH-TRU waste. The largest site (Hanford) would incur additional storage costs over the 150-year period due to WIPP emplacement limitations. The waste treatment facility life-cycle costs would be $28.7 billion (in 1994 dollars).

Table 5-38
Life-Cycle Costs Under Action Alternative 2C
(in millions of 1994 dollars)[a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste and RH-TRU Waste	CH-TRU Waste and RH-TRU Waste	CH-TRU Waste and RH-TRU Waste
Treatment Facilities[b]	8,300	9,600	18,000	8,700	2,000	10,700	28,700	15,900
Transport by Truck	1,200	2,700	3,900	788	246	1,000	4,900	830
Transport by Regular Train	294	675	969	196	61	258	1,200	200
Transport by Dedicated Train	2,400	5,400	7,800	1,600	491	2,100	9,800	1,700
Disposal at WIPP	10,000	2,600	12,600	10,500	233	10,700	23,300	3,700
Total Life-Cycle Cost (Truck)	19,500	14,900	34,400	19,900	2,500	22,500	56,900	20,400
Total Life-Cycle Cost (Regular Rail)	18,600	12,900	31,500	19,300	2,300	21,700	53,200	19,800
Total Life-Cycle Cost (Dedicated Rail)	20,700	17,600	38,300	20,700	2,800	23,500	61,800	21,300

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.
[b] All CH-TRU waste treatment occurs at the WIPP site under this subalternative.

The RH-TRU waste transportation costs reflect consolidation of the RH-TRU waste volumes at Hanford and ORNL for treatment and shipment to WIPP. The CH-TRU transportation costs reflect consolidation of CH-TRU waste volumes at WIPP. Transportation modes analyzed included truck, regular rail service, and dedicated rail service. The life-cycle waste transportation costs would be about $4.9 billion by truck, $1.2 billion by regular rail, and $9.8 billion by dedicated rail.

The WIPP life-cycle disposal costs would be $23.3 billion. The total life-cycle costs of Action Alternative 2C would be $56.9 billion ($20.4 billion when discounted) using truck, $53.2 billion ($19.8 billion when discounted) using regular rail or $61.8 billion ($21.3 billion when discounted) using dedicated rail transportation.

5.3.7.2 Economic Impacts

TRU waste treatment activities would result in creation of additional direct, indirect, and induced jobs. Under Action Alternative 2A approximately 15,700 additional jobs would be created in the ROIs of the six treatment sites (Hanford, INEL, LANL, ORNL, RFETS, and SRS). Under Action Alternative 2B approximately 15,500 jobs would be created in the ROIs of the four treatment sites (Hanford, INEL, ORNL, and SRS). Under Action Alternative 2C approximately 10,600 jobs would be created in the ROIs of the three treatment sites (Hanford, ORNL, and WIPP).

Estimates of the impacts of Action Alternatives 2A, 2B, and 2C on employment, income, and the production of goods and services within the WIPP ROI are presented in Table 5-39. For Action Alternatives 2A and 2B, these impacts were estimated using an average annual budget of $180 million per year (in 1994 dollars) over a 150-year waste-disposal period. Over this period, the WIPP facility would remain a stable federal employer in the ROI economy, providing direct employment for 1,095 site personnel annually. Indirectly, the operation of WIPP as a waste emplacement facility (from 1998 through 2148) would annually support 2,300additional jobs in the ROI work force. The total WIPP-induced employment within the ROI is estimated to be 3,400 per year reflecting the sum of these direct and indirect employment levels.

Table 5-39
Economic Impacts within the WIPP ROI Under Action Alternatives 2A, 2B, and 2C

Economic Effect	Output of Goods & Services (millions of 1994 Dollars, unless indicated)		Labor Income (millions of 1994 Dollars)
Action Alternatives 2A and 2B			
Direct - Annual	1,095	180	50
Indirect & Induced - Annual	2,300	330	70
Total - Annual	3,400	500	120
Total -Operations (150 years)	505,700 job-years	75,800	18,000
Total - Operations Discounted	N/A	12,350	2,900
Action Alternative 2C			
Direct - Annual	2,100	350	100
Indirect & Induced - Annual	4,400	630	130
Total - Annual	6,600	980	230
Total -Operations (150 years)	982,700 job-years	147,000	35,000
Total - Operations (Discounted)	N/A	22,900	5,400

Action Alternatives 2A and 2B would not be expected to result in any socioeconomic impacts in the WIPP ROI beyond those associated with WIPP disposal operations, such as additional government-provided goods or services (schools, police, fire protection, and health protection), or major capital investments in public infrastructure within the ROI. Action Alternatives 2A and 2B would not be expected to impact the local real estate market, nor result in major changes in WIPP ROI work force population.

Under Action Alternative 2C, however, the economic impacts were estimated using an average annual budget of $350 million per year over a 150-year period. Because of the relatively larger scope of operations, Action Alternative 2C would have relatively larger economic impacts in the

WIPP ROI. The combination of treatment and emplacement operations is estimated to provide direct employment for 2,128 site personnel annually. Indirectly, the combined operations would annually support 4,400 additional jobs in the ROI work force. The total WIPP-induced employment within the ROI is estimated to be 6,600 per year, reflecting the sum of these direct and indirect employment levels.

Action Alternative 2C may have a relatively large economic impact in WIPP ROI due to the projected budget of $350 million per year, almost twice the levels observed during the 1988-1996 period. The relatively larger budget reflects waste treatment and storage costs for the CH-TRU waste inventory. Given the relatively larger scope of activities at the WIPP site, Action Alternative 2C has the potential of increasing the demand for government-provided goods and services (schools, police, fire protection, and health protection) within the ROI, as well as requiring additional capital investments in public infrastructure. Similarly, this subalternative would have the potential of increasing the level of activity within the local real estate market due to resulting changes in the WIPP ROI population and work force characteristics.

5.3.8 Transportation

This section describes the transportation impacts associated with the implementation of Action Alternatives 2A, 2B, and 2C. Descriptions of these alternatives are provided in Chapter 3. Detailed results are presented for truck transportation. Rail transportation impacts adjusted from truck results are presented in the final subsection for both the regular and dedicated rail options.

5.3.8.1 Route Characteristics and Shipment Projections

The methods used to determine route characteristics and the number of shipments for this alternative were identical to those presented in Section 5.1.8.1. Table 5-40 presents the number of shipments required under Action Alternatives 2A, 2B, and 2C.

Although the consolidation and treatment of waste would be different under each Action Alternative 2 subalternative than under the Proposed Action, those sites that would ship to WIPP would use the same routes. The one-way mileages from the treatment sites to WIPP, therefore, are the same as those presented for the Proposed Action in Table 5-5.

5.3.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation

The following subsections present the number of accidents, injuries, and fatalities expected under Action Alternatives 2A, 2B, and 2C. Table 5-41 presents a summary of these impacts as well as the pollution health effects (in fatalities), which are based upon the total miles traveled in urban areas and 9.9×10^{-8} fatalities per kilometer (1.6×10^{-7} per mile) (Rao et al. 1982).

Also included in the results of Table 5-41 are the impacts due to TRU waste consolidation prior to LDR treatment. These impacts were adjusted by comparing the mileage from the generator sites to the treatment sites with the mileage and impacts due to transporting the waste from the treatment sites to WIPP. For additional details on the adjustment process, see Appendix E.

For Action Alternative 2A, the total number of accidents, injuries and fatalities over the entire shipping campaign were estimated to be 107, 66, and 9, respectively. For Action Alternative 2B, the total numbers were 114 accidents, 69 injuries, and 9 fatalities. For Action Alternative 2C, the total numbers were 140 accidents, 87 injuries, and 12 fatalities, respectively.

Table 5-40
Number of Truck Shipments to WIPP Under Action Alternatives 2A, 2B, and 2C[a]

Waste Treatment Site	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
CH-TRU Waste									
Argonne National Laboratory - East	---	---	---	---	---	---	22	---	22
Hanford Site	8,219	2,543	10,762	8,219	2,543	10,762	11,562	7,194	18,756
Idaho National Engineering Laboratory/ANL-West	4,178	3,586	7,764	8,234	4,142	12,376	4,892	6,639	11,531
Lawrence Livermore National Laboratory	---	---	---	---	---	---	137	---	137
Los Alamos National Laboratory	2,952	557	3,509	---	---	---	4,236	1,590	5,826
Mound Plant	---	---	---	---	---	---	50	3	53
Nevada Test Site	---	---	---	---	---	---	73	---	73
Oak Ridge National Laboratory	---	---	---	---	---	---	192	8	200
Rocky Flats Environmental Technology Site	1,105	---	1,105	---	---	---	2,102	---	2,102
Savannah River Site	2,015	208	2,223	2,015	208	2,223	1,893	558	2451
Total CH-TRU Waste	18,469	6,894	25,363	18,468	6,893	25,361	25,159	15,992	41,151
RH-TRU Waste									
Hanford Site	17,730	---1,031	18,761	17,730	1,031---	18,761	17,730	1,031---	18,761
Oak Ridge National Laboratory	2,057	1,077---	3,134	2,057	1,077---	3,134	2,057	1,077---	3,134
Total RH-TRU Waste	19,787	2,108	21,895	19,787	2,108	21,895	19,787	2,108	21,895

[a] The number of shipments from sites with smaller quantities can be found in Appendix E. They range from 55 total CH-TRU shipments to 1,350 total RH-TRU shipments. Impacts from the transportation of TRU waste to the treatment sites are included in the SEIS-II transportation analysis in the table below and in Appendix E.

Table 5-41
Nonradiological Impacts of Transporting TRU Waste by Truck Under Action Alternatives 2A, 2B, and 2C

Impact	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
CH-TRU Waste									
Number of Accidents	36	15	51	42	16	58	49	35	84
Number of Injuries	23	9	32	26	9	35	32	21	53
Number of Fatalities	3	1	4	3	1	4	4	3	7
Pollution Health Effects (fatalities)	0.09	0.03	0.1	0.09	0.04	0.1	0.1	0.08	0.2
RH-TRU Waste									
Number of Accidents	51	5	56	51	5	56	51	5	56
Number of Injuries	31	3	34	31	3	34	31	3	34
Number of Fatalities	4	1	5	4	1	5	4	1	5
Pollution Health Effects (fatalities)	0.1	0.01	0.1	0.1	0.01	0.1	0.1	0.01	0.1
Total									
Number of Accidents	87	20	107	93	21	114	100	40	140
Number of Injuries	54	12	66	57	12	69	63	24	87
Number of Fatalities	7	2	9	7	2	9	8	4	12
Pollution Health Effects (fatalities)	0.2	0.04	0.2	0.2	0.05	0.3	0.2	0.09	0.3

5.3.8.3 Accident-Free Radiological Impacts from Truck Transportation

The methods used to determine accident-free radiological impacts for Action Alternatives 2A, 2B, and 2C were identical to those used for the Proposed Action.

Table 5-42 presents a summary of the accident-free radiological impacts. For Action Alternative 2A, the total occupational and nonoccupational population doses would result in 0.4 LCF and 4.5 LCFs, respectively. For Action Alternative 2B, the total occupational and nonoccupational population doses estimated would result in 0.4 LCF and 5.0 LCFs, respectively. For Action Alternative 2C, the total occupational and nonoccupational population estimated would result in 0.6 LCF and 5.7 LCFs, respectively.

Table 5-42
Aggregate Accident-Free Population Radiological Impacts from Truck Transportation Under Action Alternatives 2A, 2B, and 2C (LCFs)[a]

Impact	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
CH-TRU Waste									
Occupational	0.2	0.07	0.3	0.2	0.08	0.3	0.3	0.2	0.5
Nonoccupational									
Stops	1.3	0.5	1.8	1.6	0.5	2.1	1.7	1.1	2.8
Sharing Route	0.07	0.03	0.1	0.09	0.03	0.1	0.09	0.06	0.2
Along Route	0.03	9.7E-3	0.04	0.04	0.01	0.05	0.04	0.02	0.06
Nonoccupational - Total	1.4	0.5	1.9	1.8	0.6	2.3	1.8	1.2	3.0
RH-TRU Waste									
Occupational	0.09	8.8E-3	0.1	0.09	8.8E-3	0.1	0.09	8.8E-3	0.1
Nonoccupational									
Stops	2.3	0.2	2.5	2.3	0.2	2.5	2.3	0.2	2.5
Sharing Route	0.1	0.01	0.1	0.1	0.01	0.1	0.1	0.01	0.1
Along Route	0.05	5.5E-3	0.05	0.05	5.5E-3	0.05	0.05	5.5E-3	0.05
Nonoccupational - Total	2.4	0.2	2.6	2.5	0.2	2.7	2.5	0.2	2.7
Total CH-TRU and RH-TRU Waste									
Occupational	0.3	0.08	0.4	0.3	0.09	0.4	0.4	0.2	0.6
Nonoccupational									
Stops	3.6	0.7	4.3	3.9	0.8	4.7	4.0	1.3	5.3
Sharing Route	0.2	0.04	0.2	0.2	0.04	0.3	0.2	0.07	0.3
Along Route	0.1	0.02	0.1	0.08	0.02	0.1	0.08	0.03	0.1
Nonoccupational - Total	3.9	0.7	4.5	4.2	0.8	5.0	4.3	1.4	5.7

[a] Exposure during stops is based upon 50 individuals exposed at 20 meters. Stop time, in hours, is based upon 0.011d where d is the distance traveled in kilometers. These parameters are built into the RADTRAN code but substantially overestimate exposures from WIPP shipments. Because WIPP shipments would use 2-driver teams (eliminating the need for overnight stops to sleep) and because the shipments would stop at sites chosen, in part, for their lack of population, the actual impacts from stops would be much lower.

As in Table 5-41, Table 5-42 includes the impacts from consolidation prior to the thermal LDR treatment. For details on the adjustment method, see Appendix E.

Table 5-43 summarizes the radiological impacts to maximally exposed individuals for TRU waste shipments under Action Alternatives 2A, 2B, and 2C. Section 5.1.8.3 and Appendix E describe the methods used to estimate the impacts presented in Table 5-43. The results in Table 5-43 indicate that the departure inspectors and state inspectors would have the greatest probability of an LCF.

Table 5-43
Radiological Impacts to MEIs from Truck Transportation
Under Action Alternatives 2A, 2B, and 2C (Probability of an LCF)

Individual	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C
CH-TRU Waste			
Stuck in traffic next to shipment	2.5E-6	2.5E-6	2.5E-6
Departure Inspector	6.4E-4	6.4E-4	6.8E-4
State Vehicle Inspector	1.0E-3	1.3E-3	1.0E-3
Residing adjacent to access route	2.0E-4	2.5E-4	3.0E-4
Rest stop employee	1.5E-4	2.0E-4	1.5E-4
RH-TRU Waste			
Stuck in traffic next to shipment	5.0E-6	5.0E-6	5.0E-6
Departure Inspector	6.4E-3	6.4E-3	6.4E-3
State Vehicle Inspector	1.6E-3	1.6E-3	1.6E-3
Residing adjacent to access route	4.5E-4	4.5E-4	4.5E-4
Rest stop employee	2.0E-4	2.0E-4	2.0E-4
Total CH-TRU and RH-TRU Waste			
Stuck in traffic next to shipment	7.5E-6	7.5E-6	7.5E-6
Departure Inspector	7.0E-3	7.0E-3	7.1E-3
State Vehicle Inspector	2.6E-3	2.9E-3	2.6E-3
Residing adjacent to access route	6.5E-4	7.0E-4	7.5E-4
Rest stop employee	3.5E-4	4.0E-4	3.5E-4

5.3.8.4 Radiological Impacts from Truck Transportation Accidents

Two types of analyses were conducted for SEIS-II radiological impacts due to accidents. The first type of analysis determined the radiological impact due to accidents during transportation from treatment or generator-storage sites to WIPP. This analysis took into account eight different severities of accidents, the number of miles from each site, and the number of shipments. The results of the analyses for route-specific accidents summed over the entire shipping campaign are presented in Table 5-44.

The second type of analysis was an assessment of four conservative, bounding accident scenarios. Two involving the breach of a TRUPACT-II, and two involving the breach of an RH-72B cask. Details on the estimation of impacts from these bounding case accidents are presented in Appendix E and in Section 5.1.8. For Action Alternatives 2A and 2B, the potential radiological releases from bounding case accidents that would occur after treatment would be smaller than those presented for the Proposed Action, with less than 1 LCF estimated. Those during consolidation for treatment would be similar to those presented for the Proposed Action. For Action Alternative 2C, the transportation impacts for RH-TRU waste that has been treated would be similar to those for Action Alternatives 2A and 2B. All of the impacts due to CH-TRU waste and due to consolidation of RH-TRU waste for treatment would be similar to the impacts presented for the Proposed Action.

Table 5-44
Aggregate Radiological Population Impacts for Truck Transportation Accidents Under Action Alternatives 2A, 2B, and 2C (LCFs)

Origin	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total	Basic Inventory	Additional Inventory	Total
CH-TRU Waste									
Argonne National Laboratory-East	-----	-----	-----	-----	-----	-----	3.5E-4	-----	3.5E-4
Hanford Site	0.2	0.06	0.3	0.2	0.06	0.3	0.3	0.2	0.5
Idaho National Engineering Laboratory/ANL-W	0.06	0.05	0.1	0.1	0.06	0.2	0.07	0.09	0.2
Lawrence Livermore National Laboratory	-----	-----	-----	-----	-----	-----	1.5E-3	-----	1.5E-3
Los Alamos National Laboratory	2.0E-3	3.5E-4	2.5E-3	-----	-----	-----	3.0E-3	1.0E-3	4.0E-3
Mound Plant	-----	-----	-----	-----	-----	-----	1.0E-3	5.0E-5	1.0E-3
Nevada Test Site	-----	-----	-----	-----	-----	-----	5.0E-4	-----	5.0E-4
Oak Ridge National Laboratory	-----	-----	-----	-----	-----	-----	2.5E-3	1.0E-4	2.5E-3
Rocky Flats Environmental Technology Site	3.5E-3	-----	3.5E-3	-----	-----	-----	7.0E-3	-----	7.0E-3
Savannah River Site	0.02	2.5E-3	0.02	0.02	2.5E-3	0.02	0.02	6.0E-3	0.03
RH-TRU Waste									
Hanford Site	0.02	1.5E-3	0.03	0.02	1.5E-3	0.03	0.02	1.5E-3	0.03
Oak Ridge National Laboratory	1.5E-3	1.0E-3	2.5E-3	1.5E-3	1.0E-3	2.5E-3	1.5E-3	1.0E-3	2.5E-3
Total CH-TRU and RH-TRU Waste									
Argonne National Laboratory-East	-----	-----	-----	-----	-----	-----	3.5E-4	-----	3.5E-4
Hanford Site	0.2	0.06	0.3	0.2	0.06	0.3	0.3	0.2	0.5
Idaho National Engineering Laboratory/ANL-W	0.06	0.05	0.1	0.1	0.06	0.2	0.07	0.09	0.2
Lawrence Livermore National Laboratory	-----	-----	-----	-----	-----	-----	1.5E-3	-----	1.5E-3
Los Alamos National Laboratory	2.0E-3	3.5E-4	2.5E-3	-----	-----	-----	3.0E-3	1.0E-3	4.0E-3
Mound Plant	-----	-----	-----	-----	----	-----	1.0E-3	5.0E-5	1.0E-3
Nevada Test Site	-----	-----	-----	-----	-----	-----	5.0E-4	-----	5.0E-4
Oak Ridge National Laboratory	1.5E-3	1.0E-3	2.5E-3	1.5E-3	1.0E-3	2.5E-3	4.0E-3	1.0E-3	5.0E-3
Rocky Flats Environmental Technology Site	3.5E-3	-----	3.5E-3	-----	-----	-----	7.0E-3	-----	7.0E-3
Savannah River Site	0.02	2.5E-3	0.02	0.02	2.5E-3	0.02	0.02	6.0E-3	0.03
Total	0.3	0.1	0.4	0.3	0.1	0.4	0.4	0.3	0.7

Although the radionuclide inventory concentration for waste that is thermally treated increases by a factor of about 2.8, the thermal treatment of the waste reduces the release fraction for a bounding accident by a factor greater than 1,000. A release fraction is the quantity of material that would be released in an accident. The assumptions and methods used for these analyses are presented in Appendix E.

5.3.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents to WIPP

During a severe accident, hazardous chemical releases under Action Alternatives 2A, 2B, and 2C would not pose a threat because the waste would have been thermally treated before being

transported. Thermal treatment would eliminate the presence of all VOCs and greatly reduce the release fraction for heavy metals.

5.3.8.6 Transportation Impacts Associated with Rail Shipment

This section presents a summary of transportation impacts for both the regular and dedicated rail transportation options. These impacts were estimated by scaling the transportation impacts from truck transportation to the impacts for rail transportation. In Appendix E, each of the impact parameters are identified, and the differences between truck and rail transportation are explained. Table 5-45 presents the estimated rail impacts for Action Alternatives 2A, 2B, and 2C.

Table 5-45
Rail (Regular and Dedicated) Transportation Impacts
Under Action Alternatives 2A, 2B, and 2C

Aggregate Traffic-Related Fatalities			
Regular Rail	4	4	5
Dedicated Rail	97	103	127
Aggregate Accident-Free Impacts (LCFs)			
Occupational	0.01	0.01	0.02
Nonoccupational			
Stops	0.2	0.2	0.3
Sharing Route	1.0E-3	1.0E-3	1.5E-3
Along Route	0.06	0.06	0.09
Nonoccupational -Total	0.3	0.3	0.4
RH-TRU Waste			
Occupational	6.0E-3	6.0E-3	6.0E-3
Nonoccupational			
Stops	0.3	0.3	0.3
Sharing Route	1.5E-3	1.5E-3	1.5E-3
Along Route	0.08	0.08	0.08
Nonoccupational - Total	0.4	0.4	0.4
Total CH-TRU and RH-TRU Waste			
Occupational	0.02	0.02	0.03
Nonoccupational			
Stops	0.5	0.5	0.6
Sharing Route	2.5E-3	2.5E-3	3.0E-3
Along Route	0.1	0.1	0.2
Nonoccupational - Total	0.7	0.7	0.8
Aggregate Radiological Impacts from Rail Transportation Accidents (LCFs)			
CH-TRU Waste	0.4	0.4	0.7
RH-TRU Waste	0.03	0.03	0.03
Total CH-TRU and RH-TRU Waste	0.4	0.4	0.7

The analyses of bounding case accidents assumed similar accidents to those described in Section 5.2.8.6. For that waste treated thermally before shipment by train, the release fraction would be reduced by a factor of 1,000. However, thermal treatment increases the concentration of radionuclides by approximately a factor of 2.8. The combination of these two factors reduces the impacts for rail accidents to the following:

- For the accident with the conservative inventory in two breached TRUPACT-IIs, the total population dose under Action Alternatives 2A and 2B would result in 0.09 LCF in the exposed population. The estimated maximum individual dose would result in a

0.03 percent chance of a cancer fatality. Impacts for Action Alternative 2C would be the same as those presented for Action Alternative 1.

- For the accident with a conservative inventory in two breached RH-72Bs, the total population dose would result in 0.09 LCF in the exposed population. The estimated maximum individual dose would result in a 0.03 percent chance of a cancer fatality.

- For the accident with average concentrations of radionuclides in two breached TRUPACT-IIs, approximately 0.02 LCF in the exposed population would be expected under Action Alternatives 2A and 2B. The estimated maximum individual dose under these two subalternatives would result in a 0.02 percent chance of a cancer fatality. Impacts for Action Alternative 2C would be the same as those presented for Action Alternative 1.

- For the accident with average concentrations of radionuclides in two breached RH-72B casks, the total population dose would result in an expectation of 2×10^{-4} LCF in the population. The estimated maximum individual dose would result in a 4×10^{-4} percent chance of a cancer fatality.

5.3.9 Human Health Impacts from Waste Treatment, Storage, and Disposal Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment, lag storage, and WIPP disposal operations under Action Alternatives 2A, 2B, and 2C. Impacts from waste treatment were adjusted from those presented in the Draft WM PEIS, and a description of this adjustment is provided in Appendix B. Impacts from lag storage at the treatment sites (including WIPP under Action Alternative 2C) and WIPP disposal operations were estimated using the general methods and assumptions used for the human health analyses of the Proposed Action and Action Alternative 1. All VOCs in the waste under these subalternatives would be destroyed during thermal treatment, and all hazardous metals would be immobilized. Therefore, no routine releases of hazardous chemicals would occur in subsequent lag storage or WIPP disposal operations. Thermal treatment also concentrates the waste and radionuclides into a smaller, more dense volume. Denser waste matrices tend to decrease surface dose rates because of more self-absorption of the external radiation emitted by radionuclides in the waste. Worker radiological impacts reflect the impact of these factors. Appendix F provides additional information on the methods used to determine the impacts from lag storage and WIPP disposal operations.

5.3.9.1 Public

Impacts to the populations and to the MEIs under Action Alternatives 2A, 2B, and 2C are presented in this section; results are presented in Table 5-46. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at six DOE sites under Action Alternative 2A, four sites under Action Alternative 2B, and three sites (including WIPP) under Action Alternative 2C. Waste disposal operations would take place only at WIPP.

Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites, all lag storage sites, and at WIPP. The impacts to the MEIs from waste treatment and lag storage are presented for the highest individual waste treatment sites, while the impacts to the MEI from disposal operations are presented for an individual near WIPP. See Chapter 3 for additional information on where treatment and storage would occur.

Table 5-46
Lifetime Human Health Impacts to the Public from Waste Treatment, Lag Storage, and WIPP Disposal Operations Under Action Alternatives 2A, 2B, and 2C

Category	Waste Treatment Impacts[a]		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)
MEI[c, d]						
Basic Inventory						
2A CH-TRU Waste	8E-5 (L)	6E-12	1E-7 (L)	0	5E-8	0
2B CH-TRU Waste	2E-5 (S)	5E-12	5.E-9 (S)	0	5E-8	0
2C CH-TRU Waste	1E-4 (W)	4E-12	5E-8 (W)	0	5E-8	0
RH-TRU Waste	1E-6 (O)	6E-12 (O)	1E-9 (H)	0	7E-10	0
2A Total Waste	8E-5 (L)	6E-11 (O)	1E-7 (L)	0	5E-8	0
2B Total Waste	2E-5 (S)	6E-11 (O)	5.E-9 (S)	0	5E-8	0
2C Total Waste	1E-4 (W)	6E-11 (O)	5E-8 (W)	0	5E-8	0
Total Inventory						
2A CH-TRU Waste	9E-5 (L)	7E-12	2E-7 (L)	0	1E-7	0
2B CH-TRU Waste	2E-5 (S)	5E-12	1E-8 (S)	0	1E-7	0
2C CH-TRU Waste	3E-4 (W)	9E-12	1E-7 (W)	0	1E-7	0
RH-TRU Waste	1E-6 (O)	6E-12 (O)	2E-9 (H)	0	8E-10	0
2A Total Waste	9E-5 (L)	7E-12 (O)	2E-7 (L)	0	1E-7	0
2B Total Waste	2E-5 (S)	6E-12 (O)	1E-8 (S)	0	1E-7	0
2C Total Waste	3E-4 (W)	9E-12 (O)	1E-7 (W)	0	1E-7	0
Population[d]						
Basic Inventory						
2A CH-TRU Waste	4.0	3E-7	7E-4	0	2E-5	0
2B CH-TRU Waste	2.6	2E-7	4E-4	0	2E-5	0
2C CH-TRU Waste	0.5	2E-7	2E-5	0	2E-5	0
RH-TRU Waste	0.05	1E-7	3E-5	0	9E-7	0
2A Total Waste	4.1	4E-7	7E-4	0	2E-5	0
2B Total Waste	2.7	3E-7	4E-4	0	2E-5	0
2C Total Waste	0.6	3E-7	5E-5	0	2E-5	0
Total Inventory						
2A CH-TRU Waste	4.6	3E-7	1E-3	0	5E-5	0
2B CH-TRU Waste	2.6	2E-7	6E-4	0	5E-5	0
2C CH-TRU Waste	1.1	4E-7	5E-5	0	5E-5	0
RH-TRU Waste	0.05	1E-7	5E-5	0	1E-6	0
2A Total Waste	4.7	4E-7	1E-3	0	5E-5	0
2B Total Waste	2.7	3E-5	6E-4	0	5E-5	0
2C Total Waste	1.2	5E-7	1E-4	0	5E-5	0

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring to the MEI, and the number of LCFs in the population.
[c] L = LANL, S = SRS, O = ORNL, W = WIPP
[d] The MEI and populations evaluated for treatment, storage, and operations impacts are different.

Note: Sites in parentheses indicate where the greatest MEI impact occurs.

Waste Treatment

Radiological impacts to the public from waste treatment under Action Alternatives 2A, 2B, and 2C would be 4.7, 2.7, and 1.2 LCFs, respectively, in the total population around the waste treatment sites. No cancer incidence would be expected in the total population from hazardous chemical exposure (4×10^{-7}, 3×10^{-5}, and 5×10^{-7} cancers expected for Action Alternatives 2A, 2B, and 2C, respectively). For radiological impacts, the MEI would be at LANL for Action Alternative 2A (9×10^{-3} percent chance of an LCF), at SRS for Action Alternative 2B (2×10^{-3} percent chance of an LCF), and at WIPP for Action Alternative 2C (3×10^{-2} percent chance of an LCF). Hazardous chemical impacts would not exceed a 9×10^{-10} percent chance of a cancer incidence at any site. No noncarcinogenic health effects would occur. The maximum HIs for the MEIs would be 2×10^{-8}

(for Action Alternative 2A), 5 x 10^{-9} (for Action Alternative 2B), and 1 x 10^{-7} (for Action Alternative 2C). No health effect is predicted unless the HI is 1 or higher.

Lag Storage

Only radiological impacts would result from lag storage because VOCs would be removed by thermal treatment under Action Alternatives 2A, 2B, and 2C. No LCFs would be expected in the total population around the lag storage sites under any of the alternatives, with 1 x 10^{-3}, 6 x 10^{-4}, and 1 x 10^{-4} LCFs expected under Action Alternatives 2A, 2B, and 2C, respectively. The MEI would be at LANL for Action Alternative 2A (2 x 10^{-5} percent chance of an LCF), at SRS for Action Alternative 2B (1 x 10^{-6} percent chance of an LCF), and at WIPP for Action Alternative 2C (1 x 10^{-5} percent chance of an LCF). No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

WIPP Disposal Operations

Only radiological impacts would result from disposal operations at WIPP because VOCs would be removed by thermal treatment. No LCFs would be expected in the population around WIPP from radiation exposure, with 5 x 10^{-5} LCFs expected under all three of the subalternatives.

The MEI was assumed to be located at the Land Withdrawal Area boundary, the closest point at which an individual could reside. The MEI would have a 1 x 10^{-5} percent chance of an LCF from radiation exposure under all three subalternatives. No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

5.3.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under Action Alternatives 2A, 2B, and 2C are presented in this section; results are presented in Table 5-47. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, handling or disposal of waste. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different noninvolved worker populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at six DOE sites under Action Alternative 2A, four sites under Action Alternative 2B, and three sites (including WIPP) under Action Alternative 2C. Waste disposal operations would take place only at WIPP.

The impacts to the maximally exposed noninvolved worker from waste treatment and lag storage are presented for the highest individual waste treatment sites. The maximally exposed noninvolved worker from disposal operations would be at the WIPP site and was assumed to work continuously at the location where emissions have the least atmospheric dispersion and thus the greatest potential impact. This location was 200 meters (660 feet) east of the exhaust filter building. The maximum ground-level concentrations of any airborne contamination would be expected at this location.

Waste Treatment

No LCFs would be expected in the total noninvolved worker population at the waste treatment sites, with 0.5, 0.3, and 0.09 LCFs under Action Alternatives 2A, 2B, and 2C, respectively. No cancer incidence would be expected in the total noninvolved worker population from hazardous chemical exposure, with 1 x 10-7 cancers for each of the three subalternatives. The maximally exposed noninvolved worker for radiological impacts would be at LANL for Action Alternative 2A

Table 5-47
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations Under Action Alternatives 2A, 2B, and 2C

Category	Waste Treatment Impacts[a]		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)
Maximally Exposed Noninvolved Worker[c, d]						
Basic Inventory						
2A CH-TRU Waste	3E-4 (L)	2E-11	8E-7 (S)	0	8E-8	0
2B CH-TRU Waste	2E-4 (S)	2E-11	8E-7 (S)	0	8E-8	0
2C CH-TRU Waste	2E-4 (W)	1E-11	8E-8 (W)	0	8E-8	0
RH-TRU Waste	1E-6 (O)	4E-11 (O)	1E-8 (H)	0	2E-9	0
2A Total Waste	3E-4 (L)	4E-11 (O)	8E-7 (S)	0	8E-8	0
2B Total Waste	2E-4 (S)	4E-11 (O)	8E-7 (S)	0	8E-8	0
2C Total Waste	2E-4 (W)	4E-11 (O)	8E-8 (W)	0	8E-8	0
Total Inventory						
2A CH-TRU Waste	3E-4 (L)	2E-11	1E-6 (S)	0	2E-7	0
2B CH-TRU Waste	2E-4 (S)	2E-11	1E-6 (S)	0	2E-7	0
2C CH-TRU Waste	3E-4 (W)	3E-11	1E-7 (W)	0	2E-7	0
RH-TRU Waste	1E-6 (O)	4E-11 (O)	2E-9 (H)	0	2E-9	0
2A Total Waste	3E-4 (L)	4E-11 (O)	1E-6 (S)	0	2E-7	0
2B Total Waste	2E-4 (S)	4E-11 (O)	1E-6 (S)	0	2E-7	0
2C Total Waste	3E-4 (W)	4E-11 (O)	1E-7 (W)	0	2E-7	0
Population[d]						
Basic Inventory						
2A CH-TRU Waste	0.4	7E-8	2E-2	0	9E-5	0
2B CH-TRU Waste	0.3	6E-8	2E-2	0	9E-5	0
2C CH-TRU Waste	0.05	6E-8	7E-5	0	9E-5	0
RH-TRU Waste	2E-3	4E-8	2E-4	0	2E-6	0
2A Total Waste	0.4	1E-7	2E-2	0	9E-5	0
2B Total Waste	0.3	1E-7	2E-2	0	9E-5	0
2C Total Waste	0.05	1E-7	3E-4	0	9E-5	0
Total Inventory						
2A CH-TRU Waste	0.5	8E-8	2E-2	0	2E-4	0
2B CH-TRU Waste	0.3	6E-8	2E-2	0	2E-4	0
2C CH-TRU Waste	0.09	1E-7	2E-4	0	2E-4	0
RH-TRU Waste	2E-3	4E-8	2E-4	0	2E-6	0
2A Total Waste	0.5	1E-7	2E-2	0	2E-4	0
2B Total Waste	0.3	1E-7	2E-2	0	2E-4	0
2C Total Waste	0.09	1E-7	4E-4	0	2E-4	0

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring to the maximally exposed noninvolved worker, and the number of LCFs in the population.
[c] L = LANL, O = ORNL, S = SRS, W = WIPP
[d] The noninvolved workers considered for treatment, lag storage, and operations impacts are different.

Note: Sites in parentheses indicate where the greatest MEI impact would occur.

(3×10^{-2} percent chance of an LCF), at SRS for Action Alternative 2B (2×10^{-2} percent chance of an LCF), and at WIPP for Action Alternative 2C (3×10^{-2} percent chance of an LCF). Hazardous chemical impacts would not exceed a 4×10^{-9} percent chance of a cancer incidence at any site. No noncarcinogenic health effects would occur. The maximum HIs for the maximally exposed noninvolved worker would 2×10^{-7} (for Action Alternative 2A), 1×10^{-7} (for Action Alternative 2B), and 8×10^{-7} (for Action Alternative 2C); no health effect is predicted unless the HI is 1 or higher.

Lag Storage

Only radiological impacts would result from lag storage because VOCs would be removed by thermal treatment. No LCFs would be expected in the total noninvolved worker population at the lag storage sites under any of the alternatives, with 2×10^{-2}, 2×10^{-2}, and 4×10^{-4} LCFs expected under Action Alternatives 2A, 2B, and 2C, respectively. The maximally exposed noninvolved worker would be at SRS for Action Alternatives 2A and 2B (1×10^{-4} percent chance of an LCF), and at WIPP for Action Alternative 2C (1×10^{-5} percent chance of an LCF). No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

WIPP Disposal Operations

Only radiological impacts would result from disposal operations at WIPP because VOCs would be removed by thermal treatment. No LCFs would be expected in the noninvolved worker population at WIPP from radiation exposure, with 2×10^{-4} LCFs expected under all three subalternatives. All 1,095 WIPP employees were assumed to be exposed at the same level as the maximally exposed noninvolved worker. The maximally exposed noninvolved worker would have a 2×10^{-5} percent chance of an LCF from radiation exposure under all three subalternatives. No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

5.3.9.3 Involved Workers

Impacts to involved workers under Action Alternatives 2A, 2B and 2C are presented in this section. Results are presented in Table 5-48, and additional information is presented in Appendix F. All worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-48
Lifetime Human Health Impacts to Involved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations Under Action Alternatives 2A, 2B, and 2C[a]

	Waste Treatment Impacts[b]		Lag Storage Impacts		WIPP Disposal Operations Impacts	
Category	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)	Hazardous Chemical (Cancer Incidence)
Population						
Basic Inventory					(36 workers)	
2A CH-TRU Waste	2.1	9E-5	0.09	0	0.05	0
2B CH-TRU Waste	2.4	1E-4	0.08	0	0.05	0
2C CH-TRU Waste	1.7	2E-4	0.08	0	0.05	0
RH-TRU Waste	0.2	1E-5	≤0.09	0	≤0.04	0
2A Total Waste	2.3	1E-4	≤0.2	0	≤0.08	0
2B Total Waste	2.6	1E-4	≤0.2	0	≤0.08	0
2C Total Waste	1.9	2E-4	≤0.2	0	≤0.08	0
Total Inventory					(36 workers)	
2A CH-TRU Waste	4.4	2E-4	0.2	0	0.1	0
2B CH-TRU Waste	4.5	2E-4	0.2	0	0.1	0
2C CH-TRU Waste	2.9	4E-4	0.2	0	0.1	0
RH-TRU Waste	0.2	1E-5	≤0.2	0	≤0.1	0
2A Total Waste	4.6	2E-4	≤0.4	0	≤0.2	0
2B Total Waste	4.7	2E-4	≤0.4	0	≤0.2	0
2C Total Waste	3.1	4E-4	≤0.4	0	≤0.2	0

[a] The workers considered for treatment impacts, lag storage impacts, and operations impacts are different.
[b] Adapted from the Draft WM PEIS (DOE 1995f).

Waste Treatment

Radiological impacts to the involved worker population from waste treatment would be greater than nonradiological impacts. Up to 4.6, 4.7, and 3.1 radiation-related LCFs could occur in the worker population under Action Alternatives 2A, 2B, and 2C, respectively, while no cancer incidence (2×10^{-4}, 2×10^{-4}, and 4×10^{-4} cancers, respectively) would be expected from hazardous chemical exposure. No noncarcinogenic health effects would occur because the maximum exposure index for a waste treatment worker under any of the subalternatives would be 6×10^{-3} (for Action Alternatives 2A and 2B), and 5×10^{-3} (for Action Alternative 2C). No health effect is predicted unless the exposure index is 1 or higher.

Lag Storage

Lag storage would take place under all three subalternatives. Radiological impacts to the lag storage involved worker population would be less than 0.4 LCF under each subalternative. No hazardous chemical impacts, either carcinogenic or noncarcinogenic, would occur because of the removal of VOCs from the waste during thermal treatment. Involved worker lag storage impacts would be larger from CH-TRU waste storage operations than from RH-TRU waste storage operations. Impacts from RH-TRU waste lag storage operations would be less because of remote RH-TRU waste handling and greater administrative controls for RH-TRU waste. Lag storage impacts would be assessed in future site-wide or project-specific NEPA reviews.

The impacts from CH-TRU waste would be from the external radiation dose received during waste container handling. Potential radiological impacts from inhalation of radioactive gases released from waste containers would be negligible. Involved worker impacts from lag storage were calculated by assuming waste handlers would spend 2 hours every workday at 1 meter (3.3 feet) from the CH-TRU waste containers and were assumed to be exposed over a 35-year career. Container dose rates were decay-corrected over 35 years, and all sites were assumed to have 20 percent of the Total Inventory contained in storage at all times.

WIPP Disposal Operations

Radiological impacts to the involved worker population at WIPP from disposal operations would be less than 0.2 LCF for each subalternative. WIPP involved worker radiological impact estimates were made assuming each involved worker who handled CH-TRU waste would receive a radiation dose (TEDE) of 1 rem per year. Impacts to involved workers from RH-TRU waste handling were assumed to be the same or less than those from CH-TRU waste handling. This assumption is conservative because RH-TRU waste is typically handled using remote-handling equipment, workers are usually protected by radiation shielding, and stricter administrative procedures are used. The impact from handling RH-TRU waste, therefore, would probably be less than the impact from handling CH-TRU waste. No hazardous chemical impacts, either carcinogenic or noncarcinogenic, would occur because of the removal of VOCs from the waste during thermal treatment.

5.3.10 Facility Accidents

This section describes potential impacts of facility accidents at the treatment sites from thermal treatment of waste, from waste storage after treatment but before shipment to WIPP, and at WIPP from waste management and disposal. Impacts of treatment and storage were evaluated at seven treatment sites (Hanford, LANL, INEL, SRS, RFETS, ORNL, and WIPP); these seven sites would treat and store all of the CH-TRU and RH-TRU waste under the Action Alternative 2 subalternatives. The difference between Action Alternatives 2A and 2B is that no CH-TRU waste

treatment and storage (and no impacts) would occur at LANL and RFETS under Action Alternative 2B. CH-TRU waste treatment and storage would occur only at WIPP under Action Alternative 2C.

Inhalation would be the dominant exposure pathway for accidental releases of radionuclides and hazardous chemicals. Radiological impacts are potentially much greater than hazardous chemical impacts and are dominated by inhalation of transuranic radionuclides. Details of the methods and assumptions used and complete accident descriptions and results are provided in Appendix G.

5.3.10.1 Waste Treatment Accidents

Three potential waste treatment accidents were evaluated for the Action Alternative 2 subalternatives; they are shown in Table 5-49. The results are presented only for accidents involving CH-TRU waste. The results from these accidents would be greater than results on similar accidents involving RH-TRU waste because CH-TRU waste contains a higher concentration of transuranic radionuclides.

Table 5-49
Treatment Accident Scenarios Evaluated for the Action Alternative 2 Subalternatives

Accident Scenarios	Annual Occurrence Frequency	Description
Drum Failure (Accident Scenario T4)	0.01	Cover block falls on a drum filled with hot glass causing shattering of glass.
Steam Explosion (Accident Scenario T5)	1E-4	Steam explosion in glass melter causes fragmentation of glass.
Earthquake (Accident Scenario T6)	1E-5 or less	A beyond-design-basis earthquake collapses the roof, causing drums to rupture and HEPA filters to fail.

The potential accident impacts at the six major sites that would treat and store the greatest volume of CH-TRU waste were evaluated in detail: Hanford, INEL, LANL, RFETS, ORNL, SRS for Action Alternatives 2A and 2B. For Action Alternative 2C, impacts were evaluated at WIPP for the treatment of CH-TRU waste.

Treatment accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a beyond-design-basis natural disaster accident. Accident analysis information is presented in Appendix G.

Estimated radiological impacts are presented as the number of LCFs in the exposed population and the percent chance of an LCF occurring in MEIs (in the tables the probability of an LCF is presented). Carcinogenic and noncarcinogenic impacts from hazardous chemicals, both VOCs and hazardous metals, were estimated. Carcinogenic impacts are presented as the number of cancers in the exposed population and the percent chance of cancer for MEIs. Noncarcinogenic impacts from exposure to VOCs and hazardous metals were estimated by two different methods for the drum failure and steam explosion scenarios (Accident Scenarios T4 and T5, respectively): IDLH-equivalent ratios and ERPG ratios. Only IDLH-equivalent ratios were calculated for the

catastrophic treatment facility failure of the earthquake (Accident Scenario T6). The potential noncarcinogenic impacts identified by ERPG ratios would be of minor importance during such a catastrophic event and its consequent site-operations upheaval.

In general, potential radiological impacts were found to be higher than hazardous chemical impacts, which would be very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-50. Impacts to the maximally exposed involved worker are addressed qualitatively.

Table 5-50
Radiological Impacts of Treatment Accidents for the Action Alternatives 2 Subalternatives

Accident Scenarios	Population (Number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Drum Failure (Accident Scenario T4)	Maximum: 4E-5 (ORNL)	Maximum: 3E-8 (ORNL)	Maximum: 4E-8 (RFETS)
Steam Explosion (Accident Scenario T5)	Maximum: 2E-3 (ORNL)	Maximum: 1E-8 (ORNL)	Maximum: 3E-6 (RFETS)
Earthquake (Accident Scenario T6)	Hanford: 20 INEL: 0.9 LANL: 8 RFETS: 20 ORNL: 30 SRS: 20 WIPP: 1	Hanford: 5E-3 INEL: 4E-4 LANL: 0.01 RFETS: 1E-3 ORNL: 0.02 SRS: 1E-4 WIPP: 0.01	Hanford: 0.03 INEL: 6E-3 LANL: 0.02 RFETS: 5E-3 ORNL: 0.02 SRS: 0.01 WIPP: 0.01

Public

Under Action Alternatives 2A and 2B, population impacts from treatment accidents were estimated for the exposed populations around the six treatment sites. Potential impacts to the population and MEIs at the six sites vary over a wide range because of differences in the population distributions, distances to MEIs, and atmospheric dispersion factors among the sites. No LCFs would be expected in the exposed population from the drum failure or steam explosion scenarios (Accident Scenarios T4 or T5, respectively), but 30 LCFs were estimated to occur from the earthquake (Accident Scenario T6) at ORNL. Twenty LCFs were estimated at Hanford, and RFETS, due to the events of the earthquake scenario. The radiological impacts to the MEI were estimated to be the highest at ORNL for all three accidents. Impacts to the MEI due to the earthquake (Accident Scenario T6) were found to range from a 0.01 (at SRS) to 2 (at ORNL) percent chance of an LCF.

Under Action Alternative 2C, population impacts from treatment accidents were estimated for the exposed population around the WIPP site. The radiological population impacts for the drum failure, steam explosion, and earthquake scenarios (Accident Scenarios T4, T5, and T6, respectively) would be 1×10^{-6}, 9×10^{-5}, and 1.0, respectively. Impacts to the MEI due to the earthquake (Accident Scenario T6) were estimated to be a 1 percent chance of an LCF to the MEI at the WIPP site.

For the Action Alternative 2 subalternatives, all carcinogenic impacts from the drum failure or steam explosion (Accident Scenarios T4 and T5, respectively) would be attributable to hazardous metals because VOCs would be consumed by the fire or thermal treatment. Under Action

Alternatives 2A and 2B, no cancers were estimated to occur in the exposed population from the hazardous chemical releases of any accident. The maximum percent chance of cancer to the MEI would be 1 x 10^{-3} from any of the three treatment accidents. The MEIs at Hanford, LANL, RFETS, and ORNL could develop irreversible or severe health effects from both metals (lead and mercury) and VOCs (1,1,2,2-tetrachlorethane) released during the earthquake. Life threatening effects could be expected at ORNL and LANL from beryllium. Under Action Alternative 2C, no cancers were estimated to occur in the exposed population from the hazardous chemical releases of any accident. The percent chance of cancer to the WIPP MEI would be 4 x 10^{-7} from hazardous chemical releases during the earthquake.

Maximally Exposed Noninvolved Worker

Under Action Alternatives 2A and 2B, the maximally exposed noninvolved worker was assumed to be at the location of greatest impact outside of the waste treatment building. The impacts to the noninvolved worker were estimated to vary over one order of magnitude across the six sites. Radiological impacts to the maximally exposed noninvolved worker would result in a 4 x 10^{-6} percent chance of an LCF from the events of the drum failure scenario (Accident Scenario T4), 3 x 10^{-4} percent chance of an LCF from the events of the steam explosion scenario (Accident Scenario T5), and up to a 3 percent chance of an LCF (at Hanford) from the events caused by the beyond-design-basis earthquake (Accident Scenario T6).

No cancers would be expected from the release of hazardous chemicals or metals from any of the accidents; the greatest percent chance of cancer would be 1 x 10^{-6}. During the earthquake (Accident Scenario T6), the noninvolved workers at all of the sites have a chance of developing noncarcinogenic irreversible or severe health effects; life threatening effects were estimated for all sites but INEL. These effects would be expected from exposures to both VOCs and hazardous metals. Under Action Alternative 2C, the only effects due to hazardous chemicals or metals were estimated under the earthquake accident (Accident Scenario T6) where the noninvolved worker would develop irreversible health effects from exposure to 1,1,2,2-tetrachlorethane, mercury, and lead and may expect life threatening effects from beryllium.

Maximally Exposed Involved Worker

For all of the Action Alternative 2 subalternatives, no impacts to the maximally exposed involved worker would be anticipated from either the drum failure or steam explosion accidents (Accident Scenarios T4 or T5, respectively). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the events. Substantial impacts would be possible from the earthquake (Accident Scenario T6), including workers killed by debris from collapsing treatment facilities and radiation doses from TRU waste being treated. Intakes of VOCs, and hazardous metals would also be expected. If the involved worker survived the earthquake, the chance of developing a radiation-related LCF would be 100 percent. The percent chance of developing cancer from exposure to hazardous chemicals would not exceed 7 x 10^{-3}. Noncarcinogenic impacts to the involved worker are substantial, leading to irreversible and even life threatening conditions from VOCs and metals.

5.3.10.2 Waste Storage Accidents

Two potential waste storage accidents were evaluated under the Action Alternative 2 subalternatives; they are described in Table 5-51. The drum fire (Accident Scenario S2) analyzed under Action Alternative 1 is not credible for thermally treated waste because waste treatment would remove all combustible components. Results are presented only for accidents involving CH-TRU waste. These results would be greater than results for an similar accidents involving

Table 5-51
Storage Accident Scenarios Evaluated
for the Action Alternative 2 Subalternatives

Accident Scenarios	Annual Occurrence Frequency	Description
Drum Puncture, Drop, and Lid Failure (Accident Scenario S1)[a]	1E-2 to 1E-4	A forklift strikes and punctures a drum on a lower level of a stack in the storage facility. The stack is destabilized and two drums fall to the ground and lose their lids upon impact.
Drum Fire (Accident Scenario S2)	---	Not credible for thermally treated waste.
Earthquake (Accident Scenario S3)	1E-5 or less	A beyond design-basis earthquake occurs, causing the collapse of the building.

[a] Occurrence frequency for Accident Scenario S1 was taken from reference documents applicable to waste packaged to meet the planning-basis WAC. The quantity of waste handled would be lower under this alternative and frequency of occurrence would likely be lower as well.

RH-TRU waste. Lower transuranic radionuclide activity in RH-TRU waste (lower PE-Ci levels, see Table G-23 and Table G-24), lower RH-TRU waste volume, more robust waste containers for RH-TRU waste, and presumably more robust construction of RH-TRU waste storage facilities (thick concrete walls for external radiation shielding) would all combine to limit potential impacts from RH-TRU waste accidents. Waste would be stored at Hanford, INEL, RFETS, ORNL (RH-TRU only), and SRS under Action Alternative 2A; at Hanford, INEL, ORNL and SRS under Action Alternative 2B, and at WIPP, ORNL (RH-TRU only), and Hanford (RH-TRU only) under Action Alternative 2C. Impacts at a particular site were analyzed only for the subalternative that would result in the greatest potential impacts.

Storage accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design (Accident Scenario S1) and a beyond-design-basis natural disaster accident (Accident Scenario S3). CH-TRU waste involved in the accidents was assumed to have the maximum radionuclide levels allowable under the planning-basis WAC (80 PE-Ci per drum), conservative concentrations of VOCs (based on CH-TRU sampling and WAC limits), and conservative concentrations of hazardous metals. Additional details on the accident analyses are presented in Appendix G.

Estimated radiological impacts are presented as the number of LCFs in the exposed population and the percent chance of an LCF occurring in the MEI (in the tables the probability of an LCF for the MEI is presented). Carcinogenic and noncarcinogenic impacts from hazardous chemicals, both VOCs and hazardous metals, were estimated. Carcinogenic impacts are presented as the number of cancers in the exposed population and the percent chance of cancer for maximally-exposed individuals. Noncarcinogenic impacts from exposure to VOCs and hazardous metals were estimated by two different methods for the drum puncture (Accident Scenario S1): IDLH-equivalent ratio and ERPG ratios. Only IDLH-equivalent ratios were calculated for the catastrophic storage facility failure of the earthquake (Accident Scenario S3). The potential noncarcinogenic impacts identified by ERPG ratios would be of minor importance during such a catastrophic event and its consequent site-operations upheaval.

In general, potential radiological impacts would be higher than hazardous chemical impacts, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-52.

Table 5-52
Radiological Impacts of Storage Accidents for the Action Alternative 2 Subalternatives[a]

Accident Scenarios	Population (number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Drum Puncture and Lid Failure (Accident Scenario S1)	Maximum: 3E-5 (RFETS)	Maximum: 1E-8 (WIPP)	Maximum: 2E-8 (Hanford, LANL)
Earthquake (Accident Scenario S3)	Hanford: 9 INEL[b]: 0.8 LANL[c]: 2 RFETS[c]: 10 SRS: 1 WIPP[d]: 2 ORNL[e]: 9E-3	Hanford: 2E-3 INEL[b]: 3E-4 LANL[c]: 3E-3 RFETS[c]: 6E-4 SRS: 6E-5 WIPP[d]: 3E-4 ORNL[e]: 6E-6	Hanford: 0.02 INEL[b]: 6E-3 LANL[c]: 7E-3 RFETS[c]: 3E-3 SRS: 7E-3 WIPP[d]: 0.03 ORNL[e]: 9E-6

[a] The site with the greatest impact is shown in parentheses.
[b] Impacts are greatest at INEL under Action Alternative 2B.
[c] CH-TRU waste is stored at LANL and RFETS only under Action Alternative 2A.
[d] CH-TRU waste is stored at WIPP only under Action Alternative 2C.
[e] Only RH-TRU waste would be stored at ORNL.

Public

Population impacts from storage accidents were estimated for the exposed populations around the six treatment sites. Potential impacts to the population and MEIs at the six sites vary over a wide range because the population distributions, distances to MEIs, and atmospheric dispersion factors vary from site to site. No LCFs would be expected in the exposed population from the drum puncture accident (Accident Scenario S1), but LCFs were estimated to occur from the earthquake (Accident Scenario S3) at all sites; the LCFs would range from 0.8 (at INEL) to 10 (at RFETS). The radiological impacts to the MEI would be highest for the WIPP MEI under the drum puncture scenario (Accident Scenario S1), with a 1×10^{-6} percent chance of an LCF. Impacts from the earthquake scenario (Accident Scenario S3) were estimated to range from a 6×10^{-3} (at SRS) to 0.2 percent chance of an LCF (at Hanford) to the MEI.

No cancers would be expected in the exposed population from the hazardous chemical releases of any accident. The maximum percent chance of cancer to the MEI from the hazardous metal releases of either accident would be 4×10^{-7}. No noncarcinogenic impacts would be expected from either accident.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest impact outside of the waste storage facility. The impacts to the noninvolved worker were estimated to vary over a narrow range. The range was narrow because of the uniform release height assumed and the close distances considered for all noninvolved workers.

Radiological impacts to the maximally exposed noninvolved worker would result in a 2×10^{-6} percent chance of an LCF from the events of the drum puncture scenario (Accident Scenario S1) and up to a 3 percent chance of an LCF (at WIPP under Action Alternative 2C) from the events of the beyond-design-basis earthquake scenario (Accident Scenario S3).

Hazardous chemical impacts would be minor in comparison to radiological impacts. The maximum percent chance of cancer to the maximally exposed noninvolved worker from heavy metal intakes would be 5×10^{-14} from the events of the drum puncture scenario (Accident Scenario S1). The corresponding impact for the earthquake scenario (Accident Scenario S3) would be 6×10^{-7} percent chance of cancer. No noncarcinogenic impacts would be expected from any accident release.

Maximally Exposed Involved Worker

The involved worker would be the individual most seriously impacted by the two accidents analyzed. Impacts were quantitatively estimated only for the drum puncture scenario (Accident Scenario S1). The maximally exposed involved worker could potentially have a 0.4 percent chance of an LCF as a result of the radionuclide intake due to the events of the drum puncture scenario. The analysis assumed the instantaneous radioactive material releases from the three containers, expanding in a uniform hemisphere 3 meters (9.9 feet) in diameter. The worker was assumed to inhale approximately five breaths of this air prior to exiting the facility. The involved worker could have a 1×10^{-6} percent chance of cancer from estimated hazardous chemical intakes due to the drum puncture accident (Accident Scenario S1). No noncarcinogenic impacts would be expected.

Catastrophic destruction of the storage facility due to an earthquake (Accident Scenario S3) could result in death or serious injury to the maximally exposed involved worker due to falling debris and releases from stored waste.

5.3.10.3 WIPP Disposal Accidents

Seven potential accidents at WIPP during disposal operations were evaluated for the Action Alternative 2 subalternatives; they are shown in Table 5-53. Because thermal treatment would eliminate the combustibility of the waste, Accident Scenario W5, a drum fire, is not credible and was not evaluated. Five of the accidents involve only CH-TRU waste (Accident Scenarios W1 through W4 and W7), one involves only RH-TRU waste (Accident Scenario W8), and one was evaluated for impacts from CH-TRU and RH-TRU waste (Accident Scenario W6). Annual accident frequencies are one-half those of other alternatives because of the smaller waste volumes and the limited amount of waste that could be placed in each panel due to the thermal power limitation of the WIPP underground.

Potential radiological impacts are substantially higher than impacts from hazardous metals, which are very small for all accident cases. There would be no VOCs in thermally treated waste, and VOCs were the primary contributors to hazardous chemical impacts (though small) under the Proposed Action and Action Alternative 1. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below.

With the exception of the waste hoist failure (Accident Scenario W7), the impacts of postulated accidents under the Action Alternative 2 subalternatives would be less than those under the Proposed Action by at least a factor of ten. Thermal treatment also eliminates potential impacts of an RH-TRU container breach (Accident Scenario W8). In such an event, thermally treated waste would be less likely to release particles of respirable size. However, in the event of a hoist failure, the more uniform, brittle waste matrix (as compared to waste treated to planning-basis WAC) is more likely to shatter upon impact into respirable particles. The thermal treatment also concentrates the radionuclides and hazardous metals in the waste form, which also increases the

Table 5-53
WIPP Disposal Accident Scenarios
for the Action Alternative 2 Subalternatives

Accident Scenarios	Annual Occurrence Frequency	Description
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	0.05	A package of drums is dropped in the Waste Handling Building, a drum on top of the package falls and its lid seal fails.
Drop, Puncture Lid Failure in Waste Handling Building (Accident Scenario W2)	0.05	Forklift strikes and punctures drums on lower level of stack in the Waste Handling Building. A drum on the upper level falls and the lid seal fails.
Drop, Lid Failure in Underground (Accident Scenario W3)	5 E-3	Same as accident W1, but it occurs in the underground.
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	5 E-3	Same as accident 2, but it occurs in the underground.
Container Fire (Accident Scenario W5)	---	Not credible for thermally treated waste.
Hoist Failure (Accident Scenario W6)	2.3 E-7	Waste hoist braking system fails and fully loaded hoist falls to the bottom of shaft. Both CH-TRU and RH-TRU waste loads were evaluated.
Roof Fall (Accident Scenario W7)	5 E-3, Panel 1 4.5 E-7, other panels	A portion of a disposal room roof falls prior to panel closure, crushing drums and causing lid seal failures.
RH-TRU Canister Breach (Accident Scenario W8)	1 E-4 to 1 E-6	RH-TRU waste canister is breached during Waste Handling Building operations.

potential impacts. Impacts of the hoist failure are approximately five to seven times higher than those estimated for waste treated to planning-basis WAC under the Proposed Action and Action Alternative 1. Radiological impacts of accidents under the Action Alternative 2 subalternatives are shown in Table 5-54.

Public

Population impacts from WIPP disposal accidents were estimated for the 22.5 degree sector west of the site, which includes the City of Carlsbad. The population in this sector is 25,629 and would be impacted greater than any other section in the surrounding 80-kilometer (50-mile) region. Impacts to the MEI were evaluated at the point of closest public access to the DOE Exclusive Use Area boundary and the least atmosphere dispersion of facility exhaust ventilation air, which would be the location of maximum impact. This point was 300 meters (990 feet) south of the Exhaust Filter Building. No credit was taken for HEPA filtration from either the Exhaust Filter Building or the Waste Handling Building.

Radiological impacts from accidents would be higher than impacts from hazardous metals. The accident with the largest potential radiological impact to the population and the MEI would be the failure of a fully loaded waste hoist (Accident Scenario W6). Up to 24 LCFs could occur in the exposed population, and the MEI could experience a 40 percent chance of an LCF. The hoist failure accident would also result in the highest potential carcinogenic hazardous metal impact, with an estimated 3×10^{-7} cancers occurring in the exposed population and an estimated 4×10^{-7} percent chance of cancer for the MEI. No fatalities due to toxicological effects would be expected, with the MEI estimated to inhale no more than 0.02 percent of an IDLH-equivalent intake of any hazardous metal under the hoist failure accident.

Table 5-54
Radiological Impacts of WIPP Disposal Accidents for the Action Alternative 2 Subalternatives

Accident Scenarios	Population (LCFs)	MEI (probability of LCF)	Maximally Exposed Noninvolved Worker (probability of LCF)	Maximally Exposed Involved Worker (probability of LCF)
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	9 E-4	1 E-5	1 E-5	4 E-3
Drop, Puncture Lid Failure in Waste Handling Building (Accident Scenario W2)	9 E-4	1 E-5	1 E-5	4 E-3
Drop, Lid Failure in Underground (Accident Scenario W3)	7 E-4	1 E-5	8 E-6	4 E-3
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	7 E-4	1 E-5	8 E-6	4 E-3
Container Fire (Accident Scenario W5)	not credible	not credible	not credible	not credible
Hoist Failure (both CH-TRU and RH-TRU waste) (Accident Scenario W6)	CH-TRU: 24 RH-TRU: 7	CH-TRU: 0.4 RH-TRU: 0.1	CH-TRU: 0.3 RH-TRU: 0.09	See text
Roof Failure (Accident Scenario W7)	0.02	2 E-4	2 E-4	See text
RH-TRU Waste Canister Breach (Accident Scenario W8)	0	0	0	0

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker at WIPP was assumed to be located at the location of least atmospheric dispersion, 300 meters (990 feet) south of the Exhaust Filter Building, which is the same location as the MEI. The stack that exhausts the underground ventilation is elevated and, as a result, the location of least plume dispersion is some distance from the release point. Radiological impacts (shown in Table 5-54) may be slightly lower than those for the MEI because of the small different in the radiation dose-to-LCF conversion factors for workers and members of the public. Impacts from exposure to hazardous metals would be identical to those of the MEI.

Maximally Exposed Involved Worker

The potentially highest impacts to an involved worker would be underground, from failure of a fully loaded waste hoist (Accident Scenario W6) or roof fall (Accident Scenario W7). These impacts could range from negligible (workers not present, or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris). Four workers would be expected to be routinely involved in underground operations and potentially at risk from these accidents.

Radiological impacts of accidents to the maximally exposed involved worker from noncatastrophic accidents are shown in Table 5-54. Impacts would come from the drop and lid failure (Accident Scenarios W1 and W3) and drum puncture accidents (Accident Scenarios W2 and W4), all with a 0.4 percent chance of an LCF. The highest hazardous metal carcinogenic impacts to an involved

worker were estimated to be a 1 x 10^{-6} percent chance of a cancer incidence. No fatalities due to toxicological effects would be expected, with the highest percentage of the IDLH-equivalent intake being 0.05 percent.

5.3.11 Industrial Safety

A total of nine, seven, and six fatalities would occur under Action Alternatives 2A, 2B, and 2C, respectively, from industrial accidents during waste treatment at all treatment sites. These estimates were adjusted from the physical-hazard fatality estimates of the Draft WM PEIS.

Under Action Alternatives 2A, 2B and 2C, WIPP operational activities would be essentially the same as those conducted under the Proposed Action but would last approximately 150 years rather than 35 years. Decommissioning activities would be the same as those for the Proposed Action. Estimated industrial safety impacts to workers under Action Alternatives 2A, 2B, and 2C are presented in Table 5-55. Oversight and inspections by the MSHA and adherence to OSHA regulations would likely reduce actual occurrences below these estimated values.

Table 5-55
Industrial Safety Impacts from WIPP Operations and Decommissioning Under Action Alternatives 2A, 2B, and 2C

Years	Injury/Illness			Fatalities		
	Excavation[a]	Operations	Total	Excavation[a]	Operations	Total
Operations 1998-2148	93	5,250	5,343	0.2	5.2	5.4
Decommissioning 2148-2158	187	96	283	0.3	0.1	0.4
Total	280	5,346	5,626	0.5	5.3	5.8

5.3.12 Long-Term Post-Closure Performance

Analyses of the long-term impacts from WIPP for Action Alternative 2 were conducted using the same suite of computer models as for the Proposed Action. Details on the data used for flow and transport are provided in Appendix H. The radionuclide and hazardous metals inventories were increased to account for the increased inventory destined for WIPP under this alternative. A total of 7.3 x 10^6 Ci of CH-TRU waste and 5.1 x 10^6 Ci of RH-TRU waste were included for this alternative. Detailed information on the radionuclide and hazardous material inventories are provided in Appendix A. Also, the repository size was adjusted from the 10 panels of the Proposed Action to 75 panels. The material properties outside the repository were not changed from the comparable cases analyzed for the Proposed Action.

The four cases below were analyzed for Action Alternative 2:

- Case 11 considered undisturbed repository performance. Median parameter values were used for all input variables where probability distributions have been defined.

- Case 12 considered disturbed conditions resulting from an exploratory borehole that penetrates the repository and intercepts a brine pocket in the Castile Formation. Median parameters were used.

- Case 13 considered undisturbed repository conditions with 75th percentile parameter values for all input variables where probability distributions have been defined.

- Case 14 considered disturbed conditions resulting from an exploratory borehole that penetrates the repository and intercepts a pressurized brine pocket in the Castile formation. Seventy-fifth percentile parameter values were used.

As discussed in the following sections, the results of this analysis indicate that there is remarkably little difference between the amounts of radionuclide and hazardous chemical releases from the repository when the analysis is conducted using both median and 75th percentile values. The results using the 75th percentile values provide slightly greater impacts in each and are presented in the figures in this chapter. For each alternative, the analysis of both median and 75th percentile values was conducted in order to demonstrate that the results are conservative.

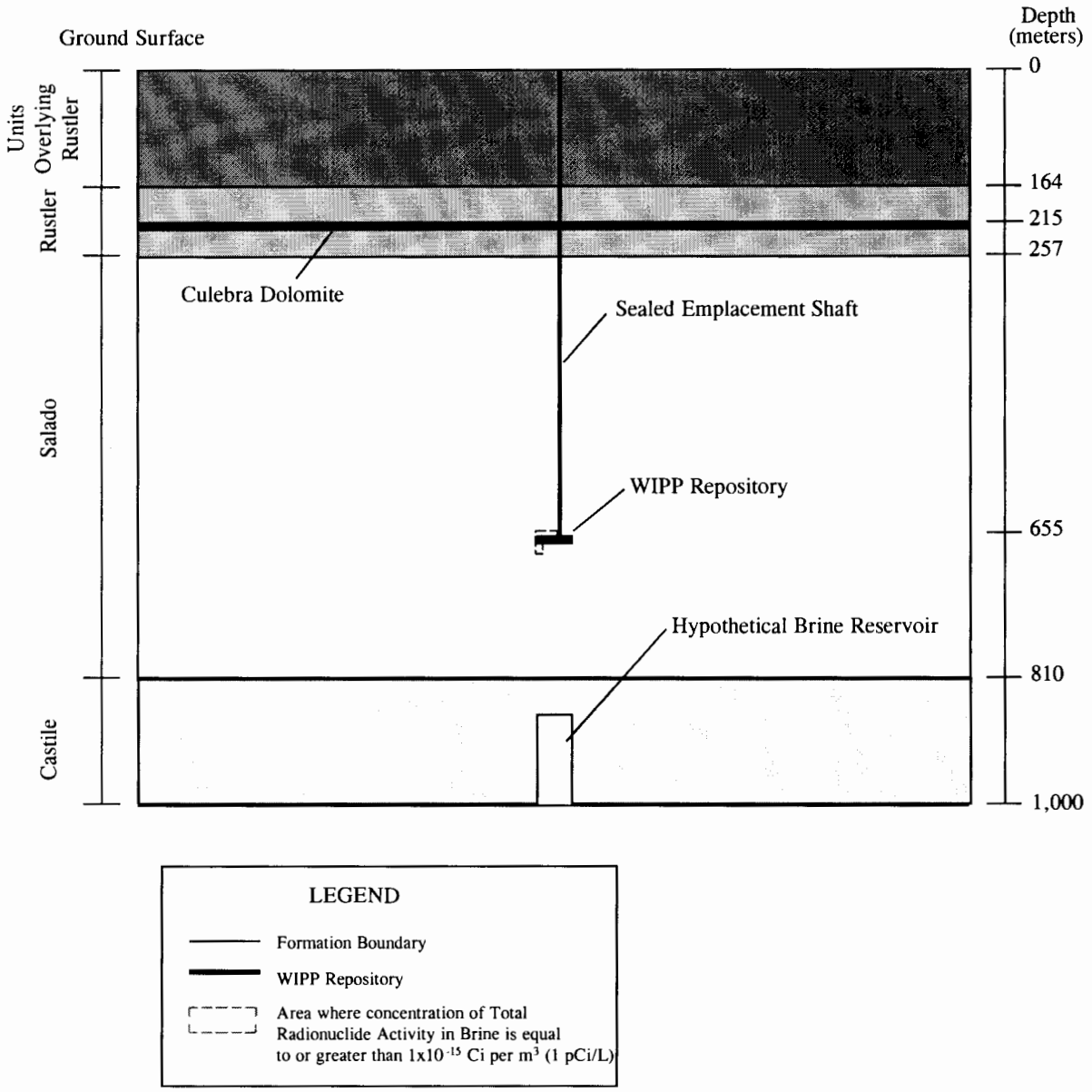
5.3.12.1 Impacts of the Undisturbed Repository Conditions

The extent of radionuclide and hazardous metal (predominately lead) migration for undisturbed conditions at 10,000 years after closure for Case 13 (using 75th percentile parameters) is schematically presented in Figure 5-4. Case 13 is presented because it resulted in more extensive migration than Case 11. Simulation results show very limited vertical and lateral migration compared to results from the Proposed Action and Action Alternative 1. The more competent waste form resulting from thermal treatment limits the migration of radionuclides beyond the disturbed rock zone just above, below, and laterally from the repository. Vertical migration of total radionuclide concentrations of 1 pCi per liter and total hazardous metals concentrations of 1 part per billion was estimated at about 15 meters (50 feet) below the bottom of the repository and about 7 meters (23 feet) above the top of the repository. Lateral migration at these concentration levels is simulated to be 90 meters (295 feet) from the edge of the repository.

For Cases 11 and 13 (the undisturbed repository cases) during the first 10,000 years: (1) no radioactive or hazardous metal waste would be released to the Culebra Dolomite; and, (2) no radionuclide concentrations greater than 1 pCi per liter or hazardous metal concentrations greater than 1 part per billion would be found beyond the 5-kilometer (3-mile) subsurface lateral boundary. Therefore, the estimated human impact was zero for these cases. Detailed data for these model runs are provided in Appendix H.

5.3.12.2 Impacts of Drilling into the Repository

The impacts to "intruders" from drilling into an undisturbed repository (Case 12 and Case 14) were evaluated, for a drilling crew member and a well-site geologist. Due to the repository loading design under Action Alternative 2, 12 waste panels would hold only CH-TRU waste and the remaining 63 panels would hold only RH-TRU waste. The estimated radionuclide release to the ground surface for Cases 12 and 14 both totaled 11.1 and 0.3 Ci respectively, for the CH-TRU waste panels and RH-TRU waste panels. The release would consist primarily of Pu-238, Pu-239, and Am-241. Hazardous metal releases totaled 8.1 and 77 kilograms (18 and 170 pounds) for the CH-TRU and RH-TRU panels, respectively, for both Cases 12 and 14. The primary metals released would be lead and mercury. Detailed results of these analyses are provided in Appendix H.



Note: Results show the area of concentration extending 15 meters (50 feet) below the repository, 7 meters (23 feet) above the repository, and 90 meters (295 feet) laterally from the edge of the repository.

Figure 5-4
Extent of Radionuclide Migration at 10,000 years With Undisturbed Conditions (Case 13)

Exposure assumptions were the same as for the corresponding cases under the Proposed Action. The radiological impacts to a drilling crew member for Case 12 and Case 14 would be a 5×10^{-2} and a 7×10^{-3} percent chance of an LCF, respectively, for CH-TRU waste panels and RH-TRU waste panels. Ninety percent of the impact due to the inadvertent ingestion of drill cuttings and 10 percent due to external radiation dose. The radionuclide with the greatest impact contribution was Am-241. The impacts for Case 12 and Case 14 are the same because the intrusion would occur before any substantial transport would occur.

The radiological impact to a well-site geologist for Case 12 and Case 14 would be a 1×10^{-4} percent chance of an LCF, with about 99 percent of the impact attributable to RH-TRU waste. The only pathway considered was external dose, and Sr-90 and Cs-137 were the major radionuclides contributing to the impact. The impacts for Case 12 and Case 14 are the same because the intrusion would occur before any substantial transport would occur.

5.3.12.3 Impacts of Drilling Intrusion into Pressurized Brine Reservoir

In this scenario, it was assumed that a deep drilling intrusion would introduce a high permeability (relative to the permeability of the intact salt) groundwater pathway from the repository to the near-surface Culebra Dolomite. Contaminants could migrate up the intrusion borehole and then move laterally through the Culebra Dolomite.

The extent of radionuclide and hazardous metal (predominantly lead) migration for disturbed conditions at 10,000 years after closure for Case 14 (using 75th percentile parameters) would be very similar to results simulated for Case 4 (shown in Figure 5-2). At 10,000 years, migration within the borehole and outward into the surrounding saltbeds around the borehole would extend upward about 20 meters (66 feet) above the repository. Migration also extends downward in the borehole and surrounding rocks to the Castile Formation and into the brine reservoir. As in the Proposed Action and Action Alternative 1, this would occur after the initial pressure in the pressurized brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole over the 10,000 years simulation. Predicted brine pressures and other modeling details associated with this simulation are provided in Appendix H.

There would be no radionuclide or hazardous metal releases into the Culebra within 10,000 years of repository closure for the deep drilling scenario for the Action Alternative 2. Therefore, there would be no impact to the cattle rancher, described in the Proposed Action.

5.3.12.4 Impacts of Potash Mining

Results for Action Alternative 2 indicated that radionuclide and hazardous chemical releases from the repository would not reach the Culebra Dolomite for either undisturbed or disturbed (borehole intrusion into the repository and a pressurized brine reservoir) conditions. Thus, the impacts of potash mining on long-term performance, as suggested in 40 CFR Part 194 and described in section 5.1.12.4, were not evaluated.

5.4 IMPACTS OF ACTION ALTERNATIVE 3

This section describes the environmental impacts associated with the implementation of Action Alternative 3. Under this alternative, WIPP would accept the Additional Inventory (except for PCB-commingled waste) as well as the Basic Inventory for disposal, and all of the waste would be treated by a shred and grout process. The total volume of waste to be treated under this alternative would be 312,000 cubic meters (11 million cubic feet) (see Tables 3-10 and 3-11). The operational

time frame would extend to the year 2200 (190 years). A detailed description of Action Alternative 3 is given in Section 3.2.4.

5.4.1 Land Use and Management

Land use impacts at the treatment sites for Action Alternative 3 would be similar to those under the Proposed Action, discussed in Section 5.1.1. Additional waste would be treated under this alternative, but the treatment time period would be extended to 35 years, and the land requirements for the number and size of the treatment facilities would be about the same as for the Proposed Action. Treatment facilities would be located to avoid sensitive and inappropriate areas (including flood plains, known cultural resource areas, and the habitats of endangered or threatened species) (DOE 1995f). Before treatment facilities would be constructed, further NEPA reviews would be undertaken at a site-wide or project-specific level.

Surface land use impacts during disposal operations under Action Alternative 3 would be similar to those under the Proposed Action, as discussed in Section 5.1.1 because the size of the surface facilities would be similar to those for the Proposed Action. A difference from the Proposed Action would be noted for decommissioning and closure; approximately 307 hectares (760 acres) would be affected due to an increased underground waste disposal area. As in the Proposed Action, the Land Withdrawal Area would be available to the public for nonintrusive surface activities following decommissioning and closure.

5.4.2 Air Quality

From TRU waste treatment, the only criteria pollutant postulated to exceed 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be CO at RFETS (20 percent) (DOE 1995f). RFETS, LLNL, and ANL-E are in nonattainment areas for some of the pollutants. In nonattainment areas, activities that introduce new sources of emissions are regulated under the General Conformity Rule. In attainment areas, regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources which will result in emissions equal to or greater than the limits set by pertinent regulations. No radiological, hazardous, or toxic air pollutants would exceed 10 percent of the applicable regulatory standard during normal (accident-free) treatment operations (see Appendix C for additional detail) (DOE 1995f). Potential minor emissions of PM_{10} may occur during construction.

At WIPP, potential air quality impacts from disposal operations under Action Alternative 3 would be similar to those anticipated under the Proposed Action. Although the volume of waste disposed of under this alternative would increase the duration of disposal activities, there would be no substantial difference in the rate of pollutant emissions on either an annual or short-term basis.

Potential air quality impacts due to the decommissioning of WIPP would be similar to those under the Proposed Action. Construction of the berm and permanent markers and other decommissioning activities would last longer than under the Proposed Action but would probably produce no substantial increase in annual pollutant emissions.

5.4.3 Biological Resources

The biological impacts at the treatment sites under Action Alternative 3 would be the same as those for the Proposed Action. Additional waste would be treated, but the size, type, and number of the treatment facilities would be similar to those discussed in Section 5.1.3. Also, construction and operation of the treatment facilities should not affect populations of nonsensitive plant and animal species. Terrestrial wildlife species probably would not be affected by airborne emissions or spills

into aquatic environments due to traffic accidents (DOE 1995f). Threatened and endangered species may be present at all of the proposed treatment sites; however, impacts to these species would depend on the actual location of the facility at a particular site. Site selection would be conducted following site-wide or project-level NEPA review and appropriate Endangered Species Act consultation, during which impacts would be assessed and mitigated, if necessary. During site selection critical habitats of species listed as threatened, endangered, or candidates would be avoided.

Federally listed, threatened and endangered, and state-listed species occur in Eddy County and potentially at the WIPP, although DOE has not observed threatened, endangered, or proposed species or critical habitats at the WIPP site during surveys conducted for recent biennial environmental compliance reports. DOE is conducting a survey to update the list of species at the site and will consult with these agencies once the survey is completed.

At WIPP, a total of 308 hectares (760 acres) of aboveground area would be affected by decommissioning, salt pile reclamation, closure, and construction of berms and permanent markers. These activities would disturb avian and small mammal habitat. The disturbed areas would probably be attractive as habitat after natural vegetation recolonizes.

5.4.4 Cultural Resources

At the treatment sites, cultural resource impacts are expected to be the same for this alternative as for the Proposed Action. Construction and operation of TRU waste management and treatment facilities could adversely affect cultural resources, but site-level cultural resource surveys would be conducted and protection measures established, where necessary, when specific facility construction locations are proposed. These surveys would be part of site-wide or project-level NEPA reviews.

At WIPP, TRU waste shipping and operational activities would not have an impact on the archaeological sites on the disturbed land; however, some sites could be affected by closure- and decommissioning-related activities. Measures for ensuring protection of known archaeological and historic resources (or others that may be inadvertently discovered during ground-disturbing activities) are discussed in the *Waste Isolation Pilot Plant Land Management Plan* (DOE 1996b). They include identifying, inventorying, evaluating, and treating cultural resources under the National Historic Preservation Act of 1966. DOE will avoid, to the maximum extent possible, sites found eligible for inclusion in the NRHP. Where avoidance is not possible, mitigation measures will be developed in consultation with the State Historic Preservation Office, Advisory Council on Historic Preservation, and the BLM.

5.4.5 Noise

The Draft WM PEIS stated that treatment sites would probably be located in industrial areas along high-volume highway corridors; therefore, ambient noise levels are not likely to increase substantially. Still, some sensitive receptors may be affected (DOE 1995f). Site-specific noise impacts will be assessed in site-wide or project-specific NEPA documents. Because all waste would travel to WIPP but only a portion of the waste would travel from or to each treatment facility, the greatest noise impacts due to transportation noise would be near the WIPP site.

At WIPP, potential noise impacts under Action Alternative 3 would be similar to those under Action Alternative 1 (Section 5.2.5). Like Action Alternative 1, the increase in noise associated with this alternative would be negligible when compared to the background noise level associated with normal automobile, truck, and rail traffic in Carlsbad, New Mexico.

5.4.6 Water Resources and Infrastructure

At the treatment sites, proposed TRU waste activities might affect on-site infrastructures although no off-site infrastructure impacts would be expected. The infrastructure elements analyzed were the capacity of on-site water, power, and wastewater systems, and on-site transportation. For Action Alternative 3, Hanford would have an increased on-site demand for wastewater treatment that would exceed 5 percent of the current demand (7 percent), and INEL would have an increase in on-site demand for power by 6.4 percent (DOE 1995f).

Minor impacts to the on-site transportation infrastructure under Action Alternative 3 may occur. These impacts would result from an increase to on-site employment of 7 percent at Hanford and INEL and 8 percent at LANL. Impacts to the off-site transportation infrastructure are not anticipated because population increases would not exceed 5 percent. On-site increases could be accommodated by existing and anticipated water supplies, power, water treatment, and transportation systems (DOE 1995f).

Negligible annual infrastructure impacts would occur at WIPP under Action Alternative 3. Existing water supply and sewer capabilities and existing and planned power and roadway resources will be able to accommodate proposed disposal operations.

5.4.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for Action Alternative 3 are presented in the following subsections.

5.4.7.1 Life-Cycle Costs

The life-cycle costs of Action Alternative 3 are presented in Table 5-56 and are discussed below. Six TRU waste treatment sites would process, treat, and package waste over a period of 35 years. In addition, the largest sites (INEL, Hanford, and ORNL) would be required to store portions of their treated waste volumes over some or all of the 190-year disposal period because of WIPP emplacement limitations. Life-cycle costs include an additional $640 million to account for treatment to planning-basis WAC of waste that would be shipped for treatment. The waste treatment facility life-cycle costs at these six sites would be $24.3 billion (in 1994 dollars).

Waste transport costs include one of three transportation options between the six consolidation sites and the WIPP site: (1) trucks, as in the Proposed Action, (2) trucks with maximum practical commercial rail, and (3) trucks with maximum practical dedicated rail. Under these options, transportation costs include the consolidation of the waste volumes at the six large sites, and then shipment to WIPP via truck or rail for emplacement. The waste transport costs would be about $6.8 billion by truck, $2.2 billion by regular rail, and $15.7 billion by dedicated rail.

The WIPP site life-cycle costs of the project would be projected to be $28.5 billion. The total life-cycle costs of Action Alternative 3 would be $59.7 billion ($18.3 billion when discounted) using trucks, $55.1 billion ($17.7 billion when discounted) using regular rail, and $68.5 billion ($19.5 billion when discounted) using dedicated rail.

Table 5-56
Life-Cycle Costs Under Action Alternative 3
(in millions of 1994 dollars)[a]

Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	9,600	4,400	13,900	10,000	470	10,500	24,400	13,800
Transport by Truck	1,400	3,600	5,000	1,500	354	1,800	6,800	910
Transport by Regular Train	962	245	1,200	1,000	22	1,000	2,200	290
Transport by Dedicated Train	6,700	1,700	8,500	7,100	157	7,200	15,700	2,100
Disposal at WIPP	12,300	3,100	15,400	12,800	285	13,100	28,500	3,600
Total Life-Cycle Cost (Truck)	23,200	11,100	34,300	24,300	1,100	25,400	59,700	18,300
Total Life-Cycle Cost (Regular Train)	22,900	7,800	30,500	23,800	780	24,600	55,000	17,700
Total Life-Cycle Cost (Dedicated Train)	28,600	9,200	37,800	29,900	910	30,800	68,500	19,500

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

5.4.7.2 Economic Impacts

TRU waste treatment activities would result in creation of additional direct, indirect, and induced jobs. Under Action Alternative 3 approximately 13,300 jobs would be created in the ROIs of the six treatment sites (Hanford, INEL, LANL, ORNL, RFETS, and SRS).

Estimates of the impacts of Action Alternative 3 on employment, income, and the production of goods and services within the ROI are presented in Table 5-57. These regional impacts were estimated using an annual average project budget of $180 million per year over a 190-year waste disposal period. Over this extended period of waste emplacement operations, WIPP would remain a stable federal employer in the ROI economy, providing direct employment for 1,095 site personnel annually. Indirectly, the operation of WIPP as a waste emplacement facility (from 2010 through 2200) would annually support 2,300 additional jobs in the ROI work force.

Total WIPP-induced employment within the ROI would be 3,400 jobs per year, reflecting the sum of these direct and indirect employment levels. Because the projected average annual project budget would be close to historical levels, Action Alternative 3 would not be expected to result in additional use of government-provided goods or services (schools, police, fire protection, and health protection), nor require major capital investments in public infrastructure within the ROI. For this same reason Action Alternative 3 would not be expected to impact the local real estate market, nor result in major changes in WIPP ROI work force population.

Table 5-57
Economic Impacts within the WIPP ROI Under Action Alternative 3

Economic Effect	Employment (Full- and Part-Time Jobs)	Output of Goods & Services (millions of 1994 Dollars)	Labor Income (millions of 1994 Dollars)
Direct - Annual	1,095	180	50
Indirect & Induced - Annual	2,300	330	70
Total - Annual	3,400	500	120
Total - Operations (190 years)	640,500 job-years	96,000	22,800
Total - Operations (Discounted)	N/A	12,370	2,900

5.4.8 Transportation

This section presents the transportation impacts for Action Alternative 3.

5.4.8.1 Route Characteristics and Shipment Projections

The methods used to estimate route characteristics and the number of shipments for Action Alternative 3 were the same as those presented in Section 5.1.8.1. Table 5-58 presents the number of shipments that would be required.

Table 5-58
Number of Truck Shipments to WIPP Under Action Alternative 3[a]

Waste Treatment Site	CH-TRU Waste			RH-TRU Waste		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Hanford Site	24,531	8,600	33,131	60,789	3,076	63,865
Idaho National Engineering Laboratory Argonne/National Laboratory-West	10,386	7,769	18,155	---	---	---
Los Alamos National Laboratory	7,628	1,907	9,535	---	---	---
Oak Ridge National Laboratory	---	---	---	7,050	3,691	10,741
Rocky Flats Environmental Technology Site	2,897	---	2,897	---	---	---
Savannah River Site	2,885	706	3,591	---	---	---
Total	48,327	18,982	67,309	67,839	6,767	74,606

[a] The number of shipments from sites with smaller quantities can be found in Appendix E. There would be 55 total CH-TRU waste shipments and 1,350 total RH-TRU waste shipments. Impacts from the transportation of TRU waste to the treatment sites is small relative to the major generator-storage sites above.

5.4.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects from Truck Transportation

Table 5-59 presents a summary of the nonradiological impacts for Action Alternative 3. The fatalities due to the pollution-related health effects of diesel fuel and the impacts due to transporting the waste to treatment sites are also presented. The number of pollution-related fatalities was based upon the total miles traveled in urban areas and a conversion factor of 9.9×10^{-8} LCFs per kilometer (1.6×10^{-7} LCFs per mile) (Rao et al. 1982). For Action Alternative 3, the total number of accidents, injuries, and fatalities over the entire shipping campaign were estimated to be 331, 208, and 25, respectively. Details on the methods used are presented in Appendix E.

Table 5-59
Nonradiological Impacts of Transporting TRU Waste by Truck Under Action Alternative 3

Category	CH-TRU Waste			RH-TRU Waste			TOTAL		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Number of Accidents	97	41	138	177	16	193	274	57	331
Number of Injuries	62	25	87	110	11	121	172	36	208
Number of Fatalities	7	3	10	13	2	15	20	5	25
Pollution Health Effects (fatalities)	0.2	0.09	0.3	0.4	0.04	0.4	0.6	0.1	0.7

5.4.8.3 Accident-Free Radiological Impacts from Truck Transportation

Accident-free radiological impacts occur during routine transportation and are the result of public and worker exposure to direct radiation at levels allowed by transportation regulations. The methods used to estimate accident-free radiological impacts for Action Alternative 3 were identical to those described for the Proposed Action.

Table 5-60 presents a summary of the accident-free radiological impacts for Action Alternative 3. It includes the impacts due to transporting waste to the treatment sites for treatment. The impacts were adjusted from those calculated for transporting the waste to WIPP from the treatment sites (see Appendix E). The total occupational and nonoccupational impacts were estimated to be 1 LCF and 13.7 LCFs, respectively.

Table 5-61 summarizes the radiological impacts to MEIs for accident-free shipments by truck under Action Alternative 3.

Table 5-60
Aggregate Accident-Free Population Radiological Impacts from Truck Transportation Under Action Alternative 3 (LCFs)[a]

Exposure Category	CH-TRU Waste			RH-TRU Waste			Total		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Occupational	0.5	0.2	0.7	0.3	0.02	0.3	0.8	0.2	1.0
Nonoccupational									
Stops	3.3	1.4	4.7	7.5	0.5	8.0	10.8	1.9	12.7
Sharing Route	0.2	0.08	0.3	0.4	0.03	0.4	0.6	0.1	0.7
Along Route	0.07	0.03	0.1	0.1	0.01	0.1	0.2	0.04	0.2
Nonoccupational - Total	3.6	1.5	5.1	8.0	0.6	8.6	11.6	2.1	13.7

[a] Exposure during stops is based upon 50 individuals exposed at 20 meters. Stop time, in hours, is based upon 0.011d where d is the distance traveled in kilometers. These parameters are built into the RADTRAN code but substantially overestimate exposures from WIPP shipments. Because WIPP shipments would use 2-driver teams (eliminating the need for overnight stops to sleep) and because the shipments would stop at sites chosen, in part, for their lack of population, the actual impacts from stops would be much lower.

Table 5-61
Radiological Impacts to MEIs from Truck Transportation Under Action Alternative 3 (Probability of an LCF)

Individual	CH-TRU Waste	RH-TRU Waste	Total
Stuck in traffic next to shipment	2.5E-6	5.0E-6	7.5E-6
Departure Inspector	7.2E-4	6.3E-3	7.0E-3
State Vehicle Inspector	1.0E-3	1.6E-3	2.6E-3
Residing adjacent to access route	5.0E-4	5.5E-4	1.1E-3
Rest stop employee	1.5E-4	2.0E-4	3.5E-4

5.4.8.4 Radiological Impacts from Truck Transportation Accidents

Two types of analyses were conducted for SEIS-II radiological impacts due to traffic accidents. The first analysis determined the radiological impacts due to accidents occurring from each of the principal treatment sites to WIPP. The results for route-specific accidents summed over the entire shipping campaign are presented in Table 5-62.

The second analysis assessed four bounding accident scenarios, two involving the breach of a TRUPACT-II and the other two involving the breach of an RH-72B cask. These assessments were to estimate the maximum potential impacts posed by a severe transportation accident. Details on the methods used to estimate impacts from bounding case accidents are presented in Section 5.1.8.4 and Appendix E.

For Action Alternative 3, the potential radiological releases from the bounding case accidents were assumed to be the same as those presented under the Proposed Action (a maximum of 16 LCFs to the population and 6 percent chance of cancer to the maximally exposed individual.) The shred and grout treatment process used for treating TRU waste under Action Alternative 3 would reduce

Table 5-62
Aggregate Radiological Population Impacts for Truck Transportation Accidents Under Action Alternative 3 (LCFs)

	CH-TRU Waste			RH-TRU Waste			Total		
Originating Site	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Argonne National Laboratory-East	---	---	---	---	---	---	---	---	---
Hanford Site	0.6	0.2	0.8	0.08	4.0E-3	0.09	0.7	0.2	0.9
Idaho National Engineering Laboratory/ANL-W	0.1	0.10	0.2	3.0E-3	5.0E-4	3.5E-3	0.1	0.1	0.2
Lawrence Livermore National Laboratory	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	5.0E-3	1.5E-3	6.5E-3	2.0E-5	1.0E-5	3.0E-5	5.0E-3	1.5E-3	6.5E-3
Oak Ridge National Laboratory	---	---	---	5.0E-3	3.0E-3	8.0E-3	5.0E-3	3.0E-3	8.0E-3
Rocky Flats Environmental Technology Site	0.01	---	0.01	---	---	---	0.01	- - -	0.01
Savannah River Site	0.03	7.5E-3	0.04	---	---	---	0.03	7.5E-3	0.04
Total LCFs							**0.9**	**0.3**	**1.2**

the void space in the drums, but increase the waste volume by approximately 20 percent. It was assumed that the release fraction for waste treated using a shred and grout process would be the same as for waste treated under the Proposed Action. The bounding accident consequences are, therefore, assumed to be the same as those for the Proposed Action (see Section 5.1.8.4).

5.4.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents

Exposures to hazardous chemical releases from a severe accident would present a negligible hazard to the exposed population under Action Alternative 3. Although the TRU waste for Action Alternative 3 would be treated using a shred and grout process and the inventory for Action Alternative 3 is larger than that for the Proposed Action, the bounding concentrations of VOCs and metals in the TRUPACT-II or RH-72B cask and the release fractions in an accident were estimated to be the same, and so potential impacts would be the same as for the Proposed Action.

5.4.8.6 Transportation Impacts Associated with Rail Shipments

This section presents a summary of transportation impacts for both regular and dedicated rail transportation. These impacts were determined by scaling the transportation impacts for truck shipments to estimate the impacts for rail. In Section 5.2.8.6 and Appendix E, the impact parameters are identified, and the differences between truck and rail transportation are explained. Table 5-63 presents the rail impacts under Action Alternative 3.

Table 5-63
Rail (Regular & Dedicated) Transportation Impacts
Under Action Alternative 3

Aggregate Traffic Related Fatalities	
Regular Rail	13
Dedicated Rail	303
Aggregate Accident-Free Impacts (LCFs)	
CH-TRU Waste	
Occupational Exposure	0.03
Nonoccupational	
Stops	0.6
Sharing Route	2.5E-3
Along Route	0.1
Nonoccupational Exposure - Total	0.7
RH-TRU Waste	
Occupational Exposure	0.02
Nonoccupational	
Stops	1.0
Sharing Route	4.5E-3
Along Route	0.2
Nonoccupational Exposure - Total	1.2
Total CH-TRU and RH-TRU Waste	
Occupational Exposure	0.05
Nonoccupational	
Stops	1.6
Sharing Route	7.0E-3
Along Route	0.3
Nonoccupational Exposure - Total	1.9
Aggregate Radiological Impacts from Rail Transportation Accidents (LCFs)	
CH-TRU Waste	1.1
RH-TRU Waste	0.1
Total CH-TRU and RH-TRU Waste	1.2

The bounding case accident analyses for rail transportation were based on assumptions presented in Section 5.2.8.6. Though the waste would be treated by a shred and grout process, the impacts would be similar to those presented for the Action Alternative 1 rail accident analyses. The greatest impacts were found for the two accidents in which conservative inventories were assumed, 32 LCFs to the exposed population and a 12 percent chance of a cancer fatality for the maximally exposed individual.

5.4.9 Human Health Impacts from Waste Treatment, Storage, and Disposal Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment, lag storage, and WIPP disposal operations under Action Alternative 3. As for other action alternatives, impacts from waste treatment were adjusted from those presented in the Draft WM PEIS; a description of the adjustments is provided in Appendix B.

Impacts from lag storage at the treatment sites and WIPP disposal operations were estimated using the general methods and assumptions used for the human health analyses of Proposed Action and Action Alternative 1. Action Alternative 3 includes the Total Inventory (except for PCB-commingled waste).

The major distinction of this alternative for human health analyses is the shred and grout treatment method. Shred and grout treatment of waste reduces gas generation and changes the quantity of VOCs emitted from the waste containers; it also results in a net waste volume increase of about 20 percent overall. The increase in volume would reduce the concentration of the radionuclides in the waste, which decreases the estimated average container dose rates. Denser waste matrices, such as grout, tend to decrease surface dose rates because of more self-absorption of the external radiation emitted by radionuclides in the waste. Worker radiological impacts reflect the impact of these factors. Appendix F provides additional information on the methods used to determine the impacts from lag storage and WIPP disposal operations.

5.4.9.1 Public

Impacts to the populations and to the MEIs under Action Alternative 3 are presented in this section; results are presented in Table 5-64. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at six DOE sites; none of them WIPP. Waste disposal operations would take place only at WIPP. Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites, all lag storage sites, and at WIPP. The impacts to the MEIs from waste treatment and lag storage are presented for the highest individual waste treatment sites; the MEI from disposal operations is near the WIPP site. See Chapter 3 for additional information on where treatment and storage would occur under Action Alternative 3.

Waste Treatment

No LCFs would be expected in the total population around the waste treatment sites (4×10^{-4} LCF); no cancer incidence (8×10^{-7} cancers) would be expected in the total population from hazardous chemical exposure. The MEI would be at LANL for radiological impacts (2×10^{-6} percent chance of an LCF). Impacts at no site would exceed a 1×10^{-9} percent chance of a cancer incidence. No noncarcinogenic health effects would occur because the maximum HI for the MEI would be 7×10^{-10}. No health effect is predicted unless the HI is 1 or higher.

Table 5-64
Lifetime Human Health Impacts to the Public from Waste Treatment, Lag Storage, and WIPP Disposal Operations Under Action Alternative 3

Category	Waste Treatment Impacts[a]		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)[c]
MEI[d, e]						
Basic Inventory						
CH-TRU waste	2E-8 (L)	1E-11	2E-7 (L)	1E-7 (L)	2E-7	5E-9
RH-TRU waste	9E-11 (H)	8E-12 (O)	1E-9 (O)	4E-8 (H)	7E-10	9E-10
Total Waste	2E-8 (L)	1E-11 (O)	2E-7 (L)	1E-7 (L)	2E-7	6E-9
Total Inventory						
CH-TRU waste	2E-8 (L)	1E-11	3E-7 (L)	2E-7(L, H)	3E-7	1E-8
RH-TRU waste	9E-11 (H)	8E-12 (O)	2E-9 (O)	4E-8 (H)	8E-10	9E-10
Total Waste	2E-8 (L)	1E-11 (O)	3E-7 (L)	3E-7 (H)	3E-7	1E-8
Population[e]						
Basic Inventory						
CH-TRU waste	4 E-4	5 E-7	1E-3	2E-3	1E-4	5E-6
RH-TRU waste	6 E-6	2 E-7	3E-5	2E-4	9E-7	5E-7
Total Waste	4E-4	7E-7	1E-3	2E-3	1E-4	6E-6
Total Inventory						
CH-TRU waste	4E-4	6E-7	2E-3	2E-3	2E-4	1E-5
RH-TRU waste	6E-6	2E-7	5E-5	2E-4	1E-6	5E-7
Total Waste	4E-4	8E-7	2E-3	2E-3	2E-4	1E-5

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF to the MEI, and the number of LCFs in the population
[c] If a panel full of CH-TRU waste remained open during the entire 70-year lifetime of the MEI and VOCs were emitted at a constant rate, the MEI lifetime risk from the CH-TRU waste would be 2E-8.
[d] L = LANL, H = Hanford, O = ORNL.
[e] The workers considered for treatment impacts, lag storage impacts, and operations impacts are different.

Note: Sites in parentheses indicate where the greatest MEI impact would occur.

Lag Storage

No LCFs would be expected in the total population around the lag storage sites (2 x 10^{-3} LCFs); no cancer incidence (2 x 10^{-3} cancers) would be expected in the total population from hazardous chemical exposure. The MEI would be at LANL for radiological impacts (3 x 10^{-5} percent chance of an LCF) and at Hanford for hazardous chemical impacts (also 3 x 10^{-5} percent chance of a cancer incidence). No noncarcinogenic health effects would occur because the maximum HI for any MEI would be 9 x 10^{-4}.

WIPP Disposal Operations

No LCFs would be expected in the population around WIPP from radiation exposure (2 x 10^{-4} LCF). No cancer incidence (1 x 10^{-5} cancers) would be expected in the population from hazardous chemical exposure.

The MEI was assumed to be located at the Land Withdrawal Area boundary, the closest point at which an individual could reside. The MEI would have a 3 x 10^{-5} percent chance of an LCF from radiation exposure and a 1 x 10^{-6} percent chance of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur; the maximum HI for the MEI would be 1 x 10^{-4}.

5.4.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under Action Alternative 3 are presented in this section; results are presented in Table 5-65. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, handling, or disposal of waste. Impacts from waste treatment, lag storage, and WIPP disposal operations are presented separately because different noninvolved worker populations and individuals would be impacted by these activities. Waste treatment and lag storage would take place at six DOE sites not including WIPP, while disposal operations would take place only at WIPP. Noninvolved worker population impacts were estimated as the total for all treatment sites, for all lag storage facilities, and at WIPP. The impacts to the maximally exposed noninvolved worker from waste treatment and lag storage are presented for the highest individual waste treatment sites. The maximally exposed noninvolved worker from disposal operations was assumed to work continuously at the WIPP location where emissions have the least atmospheric dispersion and thus the greatest potential impact. This location was 200 meters (660 feet) east of the exhaust filter building. The maximum ground-level concentrations of any airborne contamination would be expected at this location.

Table 5-65
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations Under Action Alternative 3

	Waste Treatment Impacts[a]		Lag Storage Impacts		WIPP Disposal Operations Impacts	
Category	Radiological (LCF)[b]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemicals (Cancer Incidence)
Maximally Exposed Noninvolved Worker[c, d]						
Basic Inventory						
CH-TRU Waste	2E-8 (L)	3E-11	8E-7 (S)	2E-7 (H)	2E-7	3E-8
RH-TRU Waste	4E-10 (H)	5E-11 (O)	1E-8 (O)	8E-8 (H)	2E-9	2E-9
Total Waste	2E-8 (L)	5E-11 (O)	8E-7 (S)	3E-7 (H)	2E-7	3E-8
Total Inventory						
CH-TRU Waste	2E-8 (L)	4E-11	2E-6 (S)	3E-7 (H)	3E-7	5E-8
RH-TRU Waste	4E-10 (H)	5E-11 (O)	2E-8 (O)	9E-8 (H)	2E-9	2E-9
Total Waste	2E-8 (L)	9E-11 (O)	2E-6 (S)	4E-7 (H)	3E-7	5E-8
Population[d]						
Basic Inventory						
CH-TRU Waste	4E-5	1E-7	2E-2	4E-3	2E-4	3E-5
RH-TRU Waste	2E-7	5E-8	2E-4	1E-3	2E-6	2E-6
Total Waste	4E-5	2E-7	2E-2	5E-3	2E-4	3E-5
Total Inventory						
CH-TRU Waste	4E-5	2E-7	4E-2	8E-3	3E-4	5E-5
RH-TRU Waste	2E-7	5E-8	2E-4	1E-3	2E-6	2E-6
Total Waste	4E-5	3E-7	4E-2	9E-3	3E-4	5E-5

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring to the maximally exposed noninvolved worker, and the number of LCFs in the population.
[c] L = LANL, H = Hanford, O = ORNL, S=SRS
[d] The workers considered for treatment impacts, lag storage impacts, and operations impacts are different.

Note: Sites in parentheses indicate where the greatest MEI impact would occur.

Waste Treatment

Radiological impacts from waste treatment would be somewhat greater than nonradiological impacts to noninvolved workers under Action Alternative 3. No LCFs would be expected in the total noninvolved worker population at the waste treatment sites (4×10^{-5} LCFs); no cancer incidence (3×10^{-7} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at LANL for radiological impacts (2×10^{-6} percent chance of an LCF), and at ORNL for hazardous chemical impacts (9×10^{-9} percent chance of a cancer incidence). No noncarcinogenic health effects would occur because the maximum HI for the maximally exposed noninvolved worker would be 8×10^{-9}. No health effect is predicted unless the HI is 1 or higher.

Lag Storage

No LCFs would be expected in the total noninvolved worker population at the lag storage sites (4×10^{-2} LCF); no cancer incidence (9×10^{-3} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at SRS for radiological impacts (2×10^{-4} percent chance of an LCF) and at Hanford for hazardous chemical impacts (4×10^{-5} percent chance of a cancer incidence). No noncarcinogenic health effects would occur; the maximum HI for the maximally exposed noninvolved worker would be 4×10^{-3}.

WIPP Disposal Operations

No LCFs would be expected in the WIPP noninvolved worker population from radiation exposure (3×10^{-4} LCF). VOC release estimates were the same as for the public. No cancer incidence (5×10^{-5} cancers) would be expected in the noninvolved worker population from hazardous chemical exposure. All 1,095 WIPP employees were assumed to be exposed at the same level as the maximally exposed noninvolved worker.

The maximally exposed noninvolved worker would have a 3×10^{-5} percent chance of an LCF from radiation exposure and a 5×10^{-6} percent chance of a cancer incidence from hazardous chemical exposure. No noncarcinogenic health effects would occur; the maximum HI for the maximally exposed noninvolved worker would be 1×10^{-3}.

5.4.9.3 Involved Workers

Impacts to involved workers who would handle waste during treatment, lag storage, and WIPP disposal operations under Action Alternative 3 are presented in this section. Results are presented in Table 5-66, and additional information is presented in Appendix F. All worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Waste Treatment

Up to 4.2 radiation-related LCFs could occur in the worker population while no cancer incidence (1×10^{-4} cancers) would be expected from hazardous chemical exposure. No noncarcinogenic health effects would occur. The maximum exposure index for a waste treatment worker would be 3×10^{-4}. No health effect is predicted unless the exposure index is 1 or higher.

Table 5-66
Lifetime Human Health Impacts to Involved Workers from Waste Treatment, Lag Storage, and WIPP Disposal Operations Under Action Alternative 3[a]

Category	Waste Treatment Impacts[b]		Lag Storage Impacts		WIPP Disposal Operations Impacts	
	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)
Population					(36 workers)	(36 workers)
Basic Inventory						
CH-TRU Waste	2.0	6E-5	-0.2	0.03	0.08	4E-3
RH-TRU Waste	0.01	9E-6	≤0.2	≤0.03	≤0.1	4E-4
Total Waste	2.0	7E-5	≤0.4	≤0.06	≤0.2	≤4E-3
Total Inventory						
CH-TRU Waste	4.2	1E-4	-0.3	0.06	0.2	7E-3
RH-TRU Waste	0.02	1E-5	≤0.3	≤0.06	≤ 0.1	4E-4
Total Waste	4.2	1E-4	≤0.6	≤0.1	≤ 0.2	≤7E-3

[a] The workers considered for treatment impacts, lag storage impacts, and operations impacts are different.
[b] Adapted from the Draft WM PEIS (DOE 1995f).

Lag Storage

Radiological impacts to the lag storage involved worker population would be less than 0.6 LCF, and hazardous chemical impacts would be less than 0.1 cancers. No noncarcinogenic health effects would occur. Involved worker lag storage impacts would be larger from CH-TRU waste storage operations than from RH-TRU waste storage operations. Impacts from RH-TRU waste lag storage operations would be less because of remote RH-TRU waste handling and greater administrative controls for RH-TRU waste. No specific RH-TRU lag storage impact estimates were made because specific RH-TRU waste handling configurations and procedures are unknown. RH-TRU waste lag storage impacts would be assessed in future site-wide or project-specific NEPA reviews.

The impacts from CH-TRU waste would be from the external radiation dose received during waste container handling. Potential radiological impacts from inhalation of radioactive gases released from waste containers would be negligible. Involved worker impacts from lag storage were calculated by assuming waste handlers would spend 2 hours every workday at 1 meter (3.3 feet) from the CH-TRU waste containers and were assumed to be exposed over a 35-year career. Container dose rates were decay-corrected over 35 years, and all sites were assumed to have 20 percent of the Total Inventory contained in storage at all times.

WIPP Disposal Operations

Radiological impacts to the involved worker population at WIPP from disposal operations would be less than 0.2 LCF. WIPP involved worker radiological impacts would be from external radiation dose, and it was assumed that each involved worker who handled CH-TRU waste would receive a radiation dose (TEDE) of 1 rem per year, the WIPP annual administrative radiation dose limit (DOE 1995h). Impacts to involved workers from RH-TRU waste handling were assumed to be the same or less than those from CH-TRU waste handling. This assumption is conservative because RH-TRU waste is typically handled using remote-handling equipment, workers are usually protected by radiation shielding, and stricter administrative procedures are used. The impact from handling RH-TRU waste, therefore, would probably be less than the impact from handling CH-TRU waste.

Hazardous chemical carcinogenic impacts to the involved worker population would be less than 7×10^{-3} cancers. Involved worker exposures to VOCs were evaluated for workers in the Waste Handling Building and underground. The potential carcinogenic impacts would be greatest for the individual underground worker. Noncarcinogenic health effects were also estimated for WIPP workers who would handle waste. The same methods were used as for the Proposed Action (Section 5.1.9.3).

No hazardous chemical noncarcinogenic health effects would occur. The initial maximum HI estimates for involved workers were from carbon tetrachloride, with values of 2 and 10, respectively, for workers in the Waste Handling Building and the underground. Further evaluation was conducted by comparing the worker exposure air concentration to the PEL for carbon tetrachloride. The worker air concentrations would be, at a minimum, two orders of magnitude below the PEL, so no noncarcinogenic health effects would occur. Workers were assumed to be exposed for a working lifetime of 35 years.

5.4.10 Facility Accidents

This section describes potential impacts of facility accidents at the treatment sites from the shred and grout treatment of waste, at the treatment sites from waste storage after treatment but before shipment to WIPP, and at WIPP during waste management and disposal operations. Impacts of treatment and storage accidents were evaluated at the six treatment sites (Hanford, LANL, INEL, SRS, RFETS, and ORNL) that would handle all of the CH-TRU and RH-TRU waste under Action Alternative 3.

Inhalation is the dominant exposure pathway for accidental releases of radionuclides and hazardous chemicals. Radiological impacts are potentially much greater than hazardous chemical impacts and are dominated by inhalation of transuranic radionuclides. Details of the methods and assumptions used and complete accident descriptions are provided in Appendix G.

5.4.10.1 Waste Treatment Accidents

Three potential waste treatment accidents were evaluated under Action Alternative 3; they are presented in Table 5-67. Results are presented only for accidents involving CH-TRU waste. They would be greater than similar accidents involving RH-TRU waste. Treatment accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a beyond-design-basis natural disaster accident. For the purposes of analyses, an earthquake was assumed to be the initiating event the beyond-design-basis accident for analysis (rather than a plane crash or tornado, for instance). Accident analysis information is presented in Appendix G.

Table 5-67
Treatment Accident Scenarios Evaluated Under Action Alternative 3

Accident Scenarios	Annual Occurrence Frequency	Description
Waste Spill (Accident Scenario T7)	0.01	Wet grout is spilled onto facility floor before it is placed in a drum.
Fire (Accident Scenario T8)	1E-4	Pyrophoric material inside a shredder causes shredder contents to burn.
Earthquake (Accident Scenario T9)	1E-5 or less	A beyond-design-basis earthquake collapses the roof, causing drums to rupture and HEPA filters to fail.

Estimated radiological impacts are presented as the number of LCFs in the exposed population and the percent chance of an LCF occurring in MEIs (in tables the probability of an LCF is presented for MEIs). Carcinogenic and noncarcinogenic impacts from hazardous chemicals, both VOCs and hazardous metals, were estimated. Carcinogenic impacts are presented as the number of cancers in the exposed population and the percent chance of cancer for MEIs. Noncarcinogenic impacts from exposure to VOCs and hazardous metals were estimated by two different methods for the waste spill and fire accident scenarios (Accident Scenarios T1 and T2, respectively): IDLH-equivalent ratios and ERPG ratios. Only IDLH-equivalent ratios were calculated for the catastrophic treatment facility failure of an earthquake (Accident Scenario T3). The potential noncarcinogenic impacts identified by ERPG ratios would be of minor importance during such a catastrophic event and its consequent site-operations upheaval.

In general, potential radiological impacts would be higher than hazardous chemical impacts, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-68. Impacts to the maximally exposed involved worker were addressed qualitatively.

Table 5-68
Radiological Impacts of Treatment Accidents for Action Alternative 3[a]

Accident Scenarios	Population (Number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Waste Spill (Accident Scenario T7)	Maximum: 1E-4 (ORNL)	Maximum: 1E-7 (ORNL)	Maximum: 1E-7 (ORNL, Hanford, LANL)
Fire (Accident Scenario T8)	Maximum: 1 (ORNL, Hanford, RFETS)	Maximum: 1E-3 (ORNL)	Maximum: 2E-3 (Hanford)
Earthquake (Accident Scenario T9)	Hanford: 10 INEL: 0.5 LANL: 4 RFETS: 9 ORNL: 10 SRS: 1	Hanford: 2E-3 INEL: 2E-4 LANL: 5E-3 RFETS: 5E-4 ORNL: 0.01 SRS: 6E-5	Hanford: 0.02 INEL: 3E-3 LANL: 0.01 RFETS: 2E-3 ORNL: 0.01 SRS: 5E-3

[a] The site with the greatest impact is shown in parentheses.

Public

Population impacts from treatment accidents were estimated for the exposed populations around the six treatment sites. Potential impacts to the population and MEIs at the six sites vary over a wide range because population distributions, distances to MEIs, and atmospheric dispersion factors differ among sites. No LCFs would be expected in the exposed population from the waste spill accident (Accident Scenario T7). One LCF could occur at ORNL, Hanford, and RFETS from a fire in a waste shredder (Accident Scenario T8, and up to 10 LCFs were estimated to occur from the earthquake (Accident Scenario T9) at ORNL and Hanford. The radiological impacts were estimated to be the highest to the MEI at ORNL for all three accidents. Impacts due to the earthquake (Accident Scenario T9) were estimated to range from a 2×10^{-2} (at INEL) to 1 (at ORNL) percent chance of an LCF to the MEI.

Carcinogenic impacts from VOCs would be one to five orders of magnitude greater than impacts from hazardous metals for the waste spill and earthquake accidents (Accident Scenarios T7 and T9, respectively). Hazardous metals would account for all carcinogenic impacts from the fire accident (Accident Scenario T8) because VOCs would be consumed by the fire. No cancers were estimated

to occur in the exposed population from the hazardous chemical releases of any accident. The maximum percent chance of cancer to the MEI would be 8 x 10^{-7} from any of the three treatment accidents. The ORNL, Hanford, LANL, and RFETS MEIs could all develop irreversible or severe noncarcinogenic health effects from exposure to hazardous chemicals as a result of the earthquake.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest impact outside of the waste treatment building. The impacts to the noninvolved worker were estimated to vary over two orders of magnitude across the six sites. Radiological impacts to the maximally exposed noninvolved worker would result in a 1 x 10^{-5} percent chance of an LCF from the waste spill accident (Accident Scenario T7 at ORNL, Hanford, and LANL), 0.2 percent chance of an LCF from the fire accident (Accident Scenario T8 at Hanford), and up to a 2 percent chance of an LCF (at Hanford) from the beyond-design-basis earthquake (Accident Scenario T9).

No cancers would be expected from the release of hazardous chemicals or metals from any of the accidents; the greatest percent chance of cancer would be 1 x 10^{-6}. Under the earthquake scenario (Accident Scenario T9), the maximally exposed noninvolved worker at all the sites would have a chance of developing irreversible or severe noncarcinogenic health effects, and the Hanford, LANL, and ORNL maximally exposed noninvolved workers could develop life threatening effects. These effects would be because of exposures to hazardous metals rather than VOCs.

Maximally Exposed Involved Worker

No impacts to the maximally exposed involved worker would be anticipated from either the waste spill or fire accidents (Accident Scenarios T7 or T8, respectively). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the event. Substantial impacts would be possible due to the events of the earthquake scenario (Accident Scenario T9), ranging from workers killed by debris from collapsing treatment facilities to high external radiation doses from RH-TRU waste being treated. Intakes of radionuclides, VOCs, and hazardous metals would also occur. If the involved worker were to survive the earthquake, the chance of an LCF would be 100 percent. The risk of developing a cancer from exposure to hazardous chemicals would not exceed 4 x 10^{-5}. Noncarcinogenic impacts to the involved worker would be substantial, leading to irreversible and even life threatening conditions.

5.4.10.2 Waste Storage Accidents

Three potential waste storage accidents were evaluated for Action Alternative 3; they are presented in Table 5-69. CH-TRU waste would be consolidated at five sites for lag storage under Action Alternative 3. The potential accident impacts at the five sites were evaluated in detail; the sites would be Hanford, INEL, LANL, RFETS, and SRS. A sixth site, ORNL, would store only for RH-TRU waste under Action Alternative 3.

Storage accidents analyzed include a high-frequency/low-consequence operational accident which is expected to be applicable under any facility design, a low-frequency/high-consequence operational accident, and a beyond-design-basis natural disaster accident (an earthquake). CH-TRU waste involved in the accidents was assumed to have the maximum radionuclide content allowable under the planning-basis WAC (80 PE-Ci per drum), conservative concentrations of VOCs (based on CH-TRU sampling and WAC limits), and conservative concentrations of hazardous. Additional details on the accident analyses are presented in Appendix G.

Table 5-69
Storage Accident Scenarios Evaluated Under Action Alternative 3

Accident Scenarios	Annual Occurrence Frequency	Description
Drum Puncture, Drop and Lid Failure (Accident Scenario S1)[a]	1E-2 to 1E-4	A forklift strikes and punctures a drum on a lower level of a stack in the storage facility. The stack is destablilized and two drums fall to the ground and lose their lids upon impact.
Drum Fire (Accident Scenario S2)[a]	1E-4 to 1E-6	A fire spontaneously erupts in a waste drum.
Earthquake (Accident Scenario S3)	1E- 5 or less	A beyond-design-basis earthquake occurs, causing the collapse of the storage buildings.

[a] Occurrence frequencies for Accident Scenarios S1 and S2 were taken from reference documents applicable to waste packaged to meet the planning-basis WAC. The same range of frequencies were assumed to apply to grouted waste. In reality, the frequency of occurrence of Accident Scenario S2 would probably be substantially lower for the grouted waste than for the waste treated to planning-basis WAC.

Estimated radiological impacts are presented as the number of LCFs in the exposed population and the percent chance of an LCF occurring in MEIs (in tables the probability of an LCF is presented for the MEIs). Carcinogenic and noncarcinogenic impacts from hazardous chemicals, both VOCs and hazardous metals, were estimated. Carcinogenic impacts are presented as the number of cancers in the exposed population and the percent chance of cancer for MEIs. Noncarcinogenic impacts from exposure to VOCs and hazardous metals were estimated by two different methods for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2, respectively): IDLH-equivalent ratios and ERPG ratios. Only IDLH-equivalent ratios were calculated for the catastrophic storage facility failure due to the earthquake (Accident Scenario S3). The potential noncarcinogenic impacts identified by ERPG ratios would be of minor importance during such a catastrophic event and its consequent site-operations upheaval.

In general, potential radiological impacts would be higher than hazardous chemical impacts, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below and in Table 5-70.

Table 5-70
Radiological Impacts of Storage Accidents Under Action Alternative 3[a]

Accident Scenarios	Population (number of LCFs)	MEI (probability of an LCF)	Maximally Exposed Noninvolved Worker (probability of an LCF)
Puncture and Lid Failure (Accident Scenario S1)	Maximum: 3E-5 (RFETS)	Maximum: 8E-9 (LANL)	Maximum: 2E-8 (Hanford, LANL)
Drum Fire (Accident Scenario S2)	Maximum: 5E-5 (RFETS)	Maximum: 2E-8 (LANL)	Maximum: 5E-8 (Hanford)
Earthquake (Accident Scenario S3)	Hanford: 9 INEL: 0.3 LANL: 2 RFETS: 10 SRS: 1 ORNL[b]: 0.01	Hanford: 2E-3 INEL: 1E-4 LANL: 3E-3 RFETS: 6E-4 SRS: 6E-5 ORNL[b]: 8E-6	Hanford: 0.02 INEL: 2E-3 LANL: 7E-3 RFETS: 3E-3 SRS: 7E-3 ORNL[b]: 1E-5

[a] The site with the greatest impact is shown in parentheses.
[b] Only RH-TRU waste would be stored at ORNL.

Public

Population impacts from storage accidents were estimated for the exposed populations around the five CH-TRU waste treatment sites. Potential impacts to the population and MEIs at the five sites vary over a wide range because the population distributions, distances to MEIs, and atmospheric dispersion factors differ among sites. No LCFs would be expected in the exposed population due to the drum puncture or drum fire scenarios (Accident Scenarios S1 and S2, respectively), but LCFs were estimated to occur due to the earthquake scenario (Accident Scenario S3) at most sites. The impacts due to the earthquake ranged from 0.3 (at INEL) to 10 (at RFETS) LCFs. The radiological impacts were estimated to be the highest to the MEI at LANL for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2). Impacts due to the earthquake scenario (Accident Scenario S3) were estimated to range from a 6×10^{-3} (at SRS) to 0.3 (at LANL) percent chance of an LCF to the MEI.

Carcinogenic impacts from VOCs would be two to seven orders of magnitude greater than impacts from hazardous metals for the drum puncture and earthquake accidents (Accident Scenarios S1 and S3, respectively). Hazardous metals would account for all carcinogenic impacts from the drum fire (Accident Scenario S2) because VOCs would be consumed by the fire. No cancers were estimated to occur in the exposed population from the hazardous chemical releases of any accident. The maximum percent chance of cancer to the MEI would be 3×10^{-8} from the drum puncture or drum fire scenarios (Accident Scenarios S1 and S2). The maximum percent chance of cancer to the MEI would be 3×10^{-5} for the earthquake scenario (Accident Scenario S3). No noncarcinogenic impacts would be expected for any of the three accidents evaluated.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker was assumed to be at the location of greatest impact outside of the waste storage facility. The impacts to the noninvolved worker were estimated to vary over a narrow range. The range was narrow because of the uniform release height and close distances considered.

Radiological impacts to the maximally exposed noninvolved worker would result in a 2×10^{-6} percent chance of an LCF from the drum puncture scenario (Accident Scenario S1), 5×10^{-6} percent chance of an LCF from the events of the drum fire scenario (Accident Scenario S2), and up to a 2 percent chance of an LCF (at Hanford) from the beyond-design-basis earthquake (Accident Scenario S3). Hazardous chemical impacts would be relatively minor in comparison to radiological impacts. The maximum percent chance of cancer to the maximally exposed noninvolved worker from VOC and heavy metal intakes would be 8×10^{-8} for the drum puncture and drum fire scenarios (Accident Scenarios S1 and S2). The corresponding impact for the earthquake (Accident Scenario S3) would be 2×10^{-4} percent chance of cancer. No noncarcinogenic impacts to the noninvolved worker would be expected to result from the hazardous chemical releases for the accidents evaluated.

Maximally Exposed Involved Worker

The maximally exposed involved worker would be the individual most seriously impacted by the events of the drum puncture scenario or earthquake (Accident Scenarios S1 and S3, respectively) because of close proximity to the accident. Impacts were quantitatively estimated for Accident S1 and qualitatively for Accident Scenarios S2 and S3. The worker could potentially have a 0.4 percent chance of an LCF as a result of the radionuclide intake during the events of the drum puncture scenario (Accident Scenario S1). The analysis assumed instantaneous radioactive material release from the three containers, expanding in a uniform hemisphere 3 meters (9.9 feet) in

diameter. The worker was assumed to inhale approximately five breaths of this air prior to exiting the facility. The involved worker could have a 2 x 10^{-5} percent chance of contracting cancer from hazardous chemicals inhaled following the drum puncture (Accident Scenario S1). Noncarcinogenic impacts would be only minor, reversible impacts to the maximally exposed involved worker as a result of carbon tetrachloride releases.

Impacts due to the drum fire (Accident Scenario S2) would be serious if the worker happened to be adjacent to the drum when the fire began. However, a worker's actions are not required to initiate the accident; therefore, the probability of exposure of a worker adjacent to the fire is small. The smoke released from the drum would alert workers to the incident, and it, therefore, can be reasonably assumed that workers would avoid exposure to the smoke.

Catastrophic destruction of the storage facility during an earthquake (Accident Scenario S3) could result in death or serious injury to the maximally exposed involved worker.

5.4.10.3 WIPP Disposal Accidents

Eight potential accidents at WIPP during disposal operations were evaluated; they are presented in Table 5-71. Six of the accidents involve only CH-TRU waste (Accident Scenarios W1 through W5 and W7), one involves only RH-TRU waste (Accident Scenario W8), and one was evaluated for impacts from CH-TRU and RH-TRU waste (Accident Scenario W6). The drum fire accident (Accident Scenario W5) that was evaluated under the Proposed Action and Action Alternative 1 may not be relevant for the relatively noncombustible shred-and-grout waste matrix evaluated under Action Alternative 3. Accident impacts were nevertheless estimated, and the same annual occurrence frequency for the accident under the Proposed Action and Action Alternative 1 was conservatively applied. Annual occurrence frequencies are the same in all cases as those for the Proposed Action and Action Alternative 1.

Table 5-71
WIPP Disposal Accident Scenarios for Action Alternative 3

Accident Scenarios	Annual Occurrence Frequency	Description
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	0.1	A package of drums is dropped in the Waste Handling Building, a drum on top of the package falls and its lid seal fails.
Drop, Puncture Lid Failure in the Waste Handling Building (Accident Scenario W2)	0.01	Forklift strikes and punctures drums on lower level of stack in the Waste Handling Building. A drum on the upper level falls and the lid seal fails.
Drop, Lid Failure in Underground (Accident Scenario W3)	0.01	Same as Accident Scenario W1, but it occurs in the underground.
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	0.01	Same as Accident Scenario W2, but it occurs in the underground.
Container Fire (Accident Scenario W5)	1 E-4	Contents of a drum in an underground disposal room spontaneously combusts prior to panel closure.
Hoist Failure (Accident Scenario W6)	4.5 E-7	Waste hoist braking system fails and fully loaded hoist falls to the bottom of shaft. Both CH-TRU and RH-TRU waste loads were evaluated.
Roof Fall (Accident Scenario W7)	0.01, Panel 1 9 E-7, other panels	A portion of a disposal room roof falls prior to panel closure, crushing drums and causing lid seal failures.
RH-TRU Waste Canister Breach (Accident Scenario W8)	1 E-4 to 1 E-6	RH-TRU waste canister is breached Waste Handling Building operations.

Potential radiological impacts are substantially higher than hazardous chemical impacts, which are very small for most accident cases. Estimated results for members of the public, the maximally exposed noninvolved worker, and the maximally exposed involved worker are presented below.

The greatest radiological impacts of facility accidents under Action Alternative 3 would be the same as the greatest impacts under the Action Alternative 2 subalternatives because characteristics of the thermally-treated and grouted waste forms were assumed to be the same. However, average radionuclide concentrations in the treated waste under the Action Alternative 2 subalternatives would be two to five times higher than that of Alternative Action 3 waste. Therefore, average accident impacts for the Action Alternative 2 subalternatives would be higher than those for Action Alternative 3. For the disposal room roof failure (Accident Scenario W7), the impacts of postulated accidents under Action Alternative 3 would be less than those under the Proposed Action and Action Alternative 1 by at least a factor of ten. The grout treatment increases waste volume by 20 percent overall, and therefore reduces average concentrations by 20 percent, as well. The grouted waste is less likely to release particles of respirable size in the event of a container breach. However, in the event of a hoist failure, the more uniform, grouted waste matrix (as compared to waste treated to planning-basis WAC) is more likely to shatter upon impact into respirable particles. Impacts of the hoist failure would be approximately five to seven times higher than those estimated for waste treated to planning-basis WAC under the Proposed Action and Action Alternative 1. Radiological impacts of accidents under Action Alternative 3 are shown in Table 5-72.

Public

Population impacts from WIPP disposal accidents were estimated for the 22.5 degree sector west of the site, which includes the City of Carlsbad. The population in this sector is 25,629 and would be impacted greater than any other section in the surrounding 80-kilometer (50-mile) region. Impacts to the MEI were evaluated at the point of closest public access to the DOE Exclusive Use

Table 5-72
Radiological Impacts of WIPP Disposal Accidents Under Action Alternative 3

Accident Scenarios	Population (LCFs)	MEI (probability of LCF)	Maximally Exposed Noninvolved Worker (probability of LCF)	Maximally Exposed Involved Worker (probability of LCF)
Drop, Lid Failure in Waste Handling Building (Accident Scenario W1)	9 E-4	1 E-5	1 E-5	4 E-3
Drop, Puncture Lid Failure in Waste Handling Building (Accident Scenario W2)	9 E-4	1 E-5	1 E-5	4 E-3
Drop, Lid Failure in Underground (Accident Scenario W3)	7 E-4	1 E-5	8 E-6	4 E-3
Drop, Puncture, Lid Failure in Underground (Accident Scenario W4)	7 E-4	1 E-5	8 E-6	4 E-3
Container Fire (Accident Scenario W5)	9E-4	1E-5	1E-5	not credible
Hoist Failure (CH-TRU, RH-TRU) (Accident Scenario W6)	CH-TRU: 24 RH-TRU: 7	CH-TRU: 0.4 RH-TRU: 0.1	CH-TRU: 0.3 RH-TRU: 0.09	See text
Roof Failure (Accident Scenario W7)	0.02	2 E-4	2 E-4	See text
RH-TRU Canister Breach (Accident Scenario W8)	0	0	0	0

Area boundary and the least atmospheric dispersion of facility exhaust ventilation air, which would be the location of maximum impact. This point was 300 meters (990 feet) south of the Exhaust Filter Building. No credit was taken for HEPA filtration from either the Exhaust Filter Building or the Waste Handling Building.

Radiological impacts from accidents would be higher than impacts from hazardous chemicals. The accident with the largest potential radiological impact to the population and the MEI would be the failure of a fully loaded waste hoist carrying CH-TRU waste (Accident Scenario W6). Up to 24 LCFs could occur in the exposed population, and the MEI could experience a 40 percent chance of an LCF. The roof fall accident (Accident Scenario W7) would result in the highest potential carcinogenic hazardous chemical impact, with an estimated 7×10^{-5} cancers occurring in the exposed population and an estimated 7×10^{-7} percent chance of cancer for the MEI. No fatalities due to toxicological effects would be expected, with the MEI estimated to inhale no more than 5×10^{-3} percent of an IDLH-equivalent intake of any hazardous chemical under either the hoist failure or roof fall accidents. Noncarcinogenic impact analyses based on ERPGs indicated potentially life-threatening exposures to methylene chloride from a hoist failure accident and less serious impacts from 1,1,2,2-tetrachloroethane and carbon tetrachloride exposures from a roof fall accident.

Maximally Exposed Noninvolved Worker

The maximally exposed noninvolved worker at WIPP was assumed to be located at the location of least atmospheric dispersion, 300 meters (990 feet) south of the Exhaust Filter Building, which is the same location as the MEI. The stack that exhausts the underground ventilation is elevated and, as a result, the location of least plume dispersion is some distance from the release point. Radiological impacts shown in Table 5-72 may be slightly lower than those for the MEI because of the small difference in the radiation dose-to-LCF conversion factors for workers and members of the public. The hazardous chemical impacts would be identical to those of the MEI.

Maximally Exposed Involved Worker

The potentially highest impacts to an involved worker would be underground from failure of a fully loaded waste hoist (Accident Scenario W6) or roof fall (Accident Scenario W7). These impacts could range from negligible (workers not present or warned of the falling hoist and evacuated) to catastrophic (all workers in the immediate vicinity killed by accident debris). Four workers would be expected to be routinely involved in underground operations and potentially at risk from these accidents.

Radiological impacts of accidents to the maximally exposed involved worker from noncatastrophic accidents are shown in Table 5-72. The highest impacts would come from an accident causing three drums to breach (Accident Scenarios W2 and W4), both with a 0.4 percent chance of an LCF. No fatalities due to toxicological effects would be expected with the highest percentage of the IDLH-equivalent intake being 0.1 percent for the accidents breaching three drums (Accident Scenarios W2 and W4). These same accidents, however, evaluated by ERPG ratios, might result in serious impacts from methlyene chloride exposures and minor transient impacts from carbon tetrachloride exposures.

5.4.11 Industrial Safety

Five fatalities from industrial accidents would occur under Action Alternative 3 during waste treatment at all treatment sites. This result was estimated by adjusting the physical-hazard fatality estimate of the Draft WM PEIS.

Under Action Alternative 3, WIPP operational activities would be essentially the same as those conducted under the Proposed Action but would last approximately 190 years rather than 35 years. Decommissioning activities would be the same as those for the Proposed Action. Estimated industrial safety impacts to workers under Action Alternative 3 are presented in Table 5-73. Oversight and inspections by the MSHA and adherence to OSHA regulations would probably reduce actual occurrences below these estimated values.

Table 5-73
Industrial Safety Impacts from Operations and Decommissioning Under Action Alternative 3

Years	Injury/Illness			Fatalities		
	Construction	Operations	Total	Construction	Operations	Total
Operations 1998-2200	118	6,650	6,768	0.2	6.6	6.8
Decommissioning 2200-2210	187	96	283	0.3	0.1	0.4
Total	305	6,746	7,051	0.5	6.7	7.3

5.4.12 Long-Term Post-Closure Performance

Analysis of the long-term impacts from WIPP for Action Alternative 3 was conducted using the same suite of computer models as were used for the Proposed Action. Details on the data used for flow and transport are provided in Appendix H. The radionuclide and hazardous metals inventories were increased to account for the increased inventory destined for WIPP under this alternative. A total of 7.3 x 10^6 Ci of CH-TRU waste and 5.1 x 10^6 Ci of RH-TRU waste was included for this alternative. Detailed information on the radionuclide and hazardous material inventories are provided in Appendix A. Also, the repository size was adjusted from the 10 panels for the Proposed Action to 71 panels. The material properties outside the repository were not changed from the comparable cases analyzed for the Proposed Action.

The four cases below were analyzed for Action Alternative 3:

- Case 16 considered undisturbed repository conditions. Median parameter values were used for all input variables where probability distributions have been defined.

- Case 17 considered disturbed conditions resulting from an exploratory borehole penetrates the repository and intercepts a brine pocket in the Castile Formation. Median parameters were used.

- Case 18 considered undisturbed repository. Seventy-fifth percentile parameter values were used for input variables where probability distributions have been defined.

- Case 19 considered disturbed conditions resulting from an exploratory borehole that penetrates the repository and intercepts a brine pocket in the Castile Formation. Seventy-fifth percentile parameters values were used.

As discussed in the following sections, the results of this analysis indicate that there is remarkably little difference between the amounts of radionuclide and hazardous chemical releases from the repository when the analysis is conducted using both median and 75th percentile values. The results using the 75th percentile values provide slightly greater impacts in each and are presented in

the figures in this chapter. For each alternative, the analysis of both median and 75th percentile values was conducted in order to demonstrate that the results are conservative.

5.4.12.1 Impacts of the Undisturbed Repository Conditions

For Action Alternative 3, the extent of radionuclide and hazardous metal (predominantly lead) migration for undisturbed conditions 10,000 years after closure for Case 18 (using 75th percentile parameters) would be very similar to that shown for Case 8 of Action Alternative 1. For undisturbed conditions (see Figure 5-3), simulations showed about the same amount of downward migration and greater upward and lateral migration of radionuclides and hazardous metals as found for the Proposed Action. Total radionuclide concentrations of 1 pCi per liter and total hazardous metal concentrations of one part per billion would extend about 60 meters (200 feet) below the repository, 15 meters (50 feet) above the repository, and about 3,600 meters (11,800 feet) laterally.

The plot depicting radionuclide and hazardous metal migration for undisturbed conditions using 75th percentile parameters (Case 18) was visually indistinguishable from the corresponding figure for Action Alternative 1 (see Appendix H). For Cases 16 and 18 (the undisturbed repository cases) during the first 10,000 years, the following were found: (1) no radioactive or hazardous metal waste would be released to the Culebra Dolomite and (2) no radionuclide concentrations greater than 1 pCi per liter or hazardous metal concentrations greater than one part per billion may be found beyond the 5-kilometer (3-mile) subsurface lateral boundary. Therefore, the estimated human impact was zero for these cases. Detailed data for these model runs are provided in Appendix H.

5.4.12.2 Impacts of Drilling into the Repository

The impacts to "intruders" from drilling into an undisturbed repository (Case 17 and Case 19) were evaluated for a drilling crew member and a well-site geologist. Due to the repository loading design under Action Alternative 3, one waste panel would hold only CH-TRU waste, 51 waste panels would hold only RH-TRU waste, and the remaining 19 panels would have a mixture of RH-TRU and CH-TRU waste. The estimated radionuclide releases to the ground surface from a drilling intrusion 100 years after closure for both Cases 17 and 19 would be 5.6, 0.4, 5.8 Ci for panels containing only CH-TRU waste, only RH-TRU waste, and both CH-TRU and RH-TRU waste. The releases would be primarily from plutonium-238, plutonium-239 and americium-241. Hazardous metal releases would be 4.0, 17.6, and 14.2 kilograms each for panels containing only CH-TRU waste, only RH-TRU waste and both CH-TRU and RH-TRU waste for both Cases 17 and 19. The primary metals released would be lead and mercury. Detailed results of these analyses are provided in Appendix H.

Exposure assumptions were the same as for the corresponding cases under the Proposed Action. The radiological impacts to a drilling crew member for Case 17 and Case 19 would be 2×10^{-2}, 3×10^{-2}, and 9×10^{-3} percent chance of an LCF, respectively, for CH-TRU panels, panels with both CH-TRU and RH-TRU waste, and RH-TRU waste panels. Ninety percent of the impact would be due to the inadvertent ingestion of drill cuttings and 10 percent would be due to external radiation dose. The radionuclide with the greatest impact contribution was americium-241. The impacts for Case 17 and Case 19 are the same because the intrusion would occur before any substantial transport would occur.

The radiological impact to a well site geologist for Case 17 and Case 19 would be a 3×10^{-5} percent chance of an LCF, with about 99 percent of the impact attributable to RH-TRU waste. The only pathway considered was external dose, and strontium-90 and cesium-137 were the

major radionuclides contributing to the impact. The impacts for Case 17 and Case 19 are the same because the intrusion would occur before any substantial transport would occur.

5.4.12.3 Impacts of Drilling Intrusion into a Pressurized Brine Reservoir

In this scenario, it was assumed that drilling would introduce a high permeability (relative to the permeability of the intact salt) groundwater pathway from the repository to the near-surface Culebra Dolomite. Contaminants could migrate up the intrusion borehole and then move laterally through the Culebra Dolomite.

Simulation results were similar between Case 19 of Action Alternative 3 and Case 4 of the Proposed Action. As shown in Figure 5-2, at 10,000 years, radionuclide and hazardous metal (predominantly lead) migration within the borehole and outward into the surrounding saltbeds around the borehole extends upward about 20 meters above the repository. Migration also extends downward in the borehole to the Castile Formation and into the brine reservoir. As in the other alternatives, this occurs after the initial pressure in the brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole over the 10,000 year simulation. Predicted brine pressures and other modeling details associated with this simulation are provided in Appendix H.

5.4.12.4 Impacts of Potash Mining

Results for Action Alternative 3 indicated that radionuclide and hazardous chemical releases from the repository would not reach the Culebra Dolomite for either undisturbed or disturbed (borehole intrusion into the repository and a pressurized brine reservoir) conditions. Thus, the impacts of potash mining on long-term performance, as suggested in 40 CFR Part 194 and described in Section 5.1.12.4, were not evaluated.

5.5 IMPACTS OF NO ACTION ALTERNATIVE 1

This section describes the environmental impacts associated with the implementation of No Action Alternative 1. Two subalternatives are included, one similar to Action Alternative 2A and the other similar to Action Alternative 2B. Under this alternative, the Basic Inventory and the Additional Inventory (including the PCB-commingled waste) would be shipped to treatment sites for treatment using a thermal process, but no waste would be shipped to WIPP for disposal. Instead, under No Action Alternative 1A, waste would remain at six sites in aboveground, retrievable storage. These sites are Hanford, INEL, LANL, SRS, RFETS, and ORNL. Under No Action Alternative 1B, waste would remain at four sites in aboveground, retrievable storage. These sites are Hanford, INEL, SRS and ORNL. The total consolidated, pretreatment volume of waste to be treated under this alternative would be 313,000 cubic meters (11 million cubic feet) (see Tables 3-12 through 3-15). A detailed description of No Action Alternative 1 is given in Section 3.2.5.

5.5.1 Land Use and Management

Land use impacts due to treatment under No Action Alternatives 1A and 1B would be similar to those under the Proposed Action discussed in Section 5.1.1. In no case would the treatment facilities require more than 1 percent of the available land at selected DOE locations, and the Department would have a great deal of flexibility when determining the locations of such facilities (DOE 1995f). The Department would be able to minimize impacts to on-site land use and would be able to avoid conflicts with off-site land use plans. It also would be able to avoid sensitive or inappropriate habitats, including flood plains, wetlands, known cultural resource areas, and the

habitats of threatened or endangered species. Before the sites for the treatment facilities would be selected, site-wide or project level NEPA reviews would be conducted.

Land use requirements due to storing the waste for an indefinite period of time would probably increase the land use impacts at the treatment and storage sites. The storage facilities, though, are not likely to increase the amount of land needed for overall operations at these sites to more than 1 or 2 percent of that available. Land use needs for the storage facilities, therefore, are not likely to conflict with other planned activities or impact sensitive or inappropriate areas.

At WIPP, under No Action Alternatives 1A and 1B, decommissioning and closure would begin immediately. No surface marking system would be necessary because no waste would be disposed of underground. Decommissioning, therefore, would be less extensive than under the Proposed Action and Action Alternatives 1, 2A, 2B, 2C, and 3. Surface structures in the Property Protection Area would be dismantled and removed, and the existing salt pile would either be returned to the underground, sold, or disposed of. The disturbed areas, estimated not to exceed 20 hectares (50 acres), would be returned to pre-WIPP condition to the extent possible. The restrictions of the LWA would probably be lifted and the land returned to BLM.

5.5.2 Air Quality

Air quality impacts from TRU waste treatment at the sites would be similar to those presented for Action Alternatives 2A and 2B in Section 5.3.2. For No Action Alternative 1A, the levels of criteria pollutants exceeding 10 percent of the applicable annual regulatory standard during operation of treatment facilities would be those for CO at the RFETS (24 percent) and PM_{10} at INEL (10 percent) (See Appendix C for details) (DOE 1995f). Under No Action Alternative 1B, the levels of criteria pollutants exceeding 10 percent would be PM_{10} at INEL (10 percent). RFETS, LLNL, and ANL-E, are in nonattainment areas for some pollutants (See Appendix C for details) (DOE 1995f). In nonattainment areas, activities that introduce new sources of emissions are regulated under the General Conformity Rule. In attainment areas, regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources that will result in emissions equal to or greater than the limits set by pertinent regulations.

Of hazardous or toxic air pollutant releases, only radionuclide releases could exceed 10 percent of the applicable regulatory standard. For No Action Alternative 1A, treatment-related radiological releases could reach 134 percent of the NESHAP standard at RFETS and 48 percent of the NESHAP standard at SRS. For No Action Alternative 1B, treatment-related releases could reach 48 percent of the regulatory standard at the SRS and 10 percent at the INEL (DOE 1995f). Postulated waste treatment-related releases above the regulatory standard would require mitigation measures, such as HEPA filters, to ensure they remained below the allowable limit.

At WIPP, potential air quality impacts due to decommissioning activities under No Action Alternatives 1A and 1B would be similar to those under the Proposed Action for decommissioning of the aboveground structures. There would be no construction of berms and permanent markers, so overall air quality impacts at WIPP would be less than for the Proposed Action. This alternative would also require building retrievable storage facilities at six DOE sites for the consolidation, treatment, and storage of TRU waste. Any impacts from construction of the storage facility would be from fugitive dust and equipment emissions. PM_{10} emissions may occur due to such construction; dust suppression would be used to limit these short-term impacts.

5.5.3 Biological Resources

The biological impacts at the treatment sites under No Action Alternatives 1A and 1B would be the same as those for Action Alternatives 2A and 2B. Construction and operation of the treatment and storage facilities should not affect populations of nonsensitive plant and animal species. Terrestrial wildlife species probably would not be affected by airborne emissions nor by spills into aquatic environments due to traffic accidents (DOE 1995f). Threatened and endangered species appear at all of the proposed treatment sites; however, impacts to these species would depend on the actual location of the facility at a particular site. Site selection would be conducted following appropriate Endangered Species Act consultation and site-wide or project-level NEPA review during which such impacts would be assessed and mitigated, if necessary. Critical habitats and the habitats of endangered, threatened, and proposed species would be avoided, and appropriate consultation, monitoring, and mitigation measures would be undertaken, as necessary.

At WIPP, No Action Alternatives 1A and 1B would entail beginning the immediate decommissioning of the site, including dismantling all aboveground structures and closing all shafts. No waste would be disposed of, so there would be no permanent aboveground marking of the underground waste disposal area. Only about 20 hectares (50 acres) would be disturbed. Therefore, decommissioning and closure at the WIPP site would have less potential impact than the Proposed Action.

5.5.4 Cultural Resources

At the treatment sites, cultural resource impacts would be the same for this alternative as for the Proposed Action. Construction and operation of TRU waste treatment and storage facilities could adversely affect cultural resources, but site-level cultural resource surveys would be conducted, and protection measures established, where necessary, when specific facility construction locations are proposed. Appropriate Native American tribes would be consulted, if necessary. These surveys would be in conjunction with site-wide or project-specific NEPA reviews.

At WIPP, no impacts to known cultural resource properties are anticipated under this alternative.

5.5.5 Noise

The Draft WM PEIS stated that treatment sites would probably be located in industrial areas along high-volume highway corridors; therefore, ambient noise levels are not likely to increase substantially. Still, the Draft WM PEIS states that some sensitive receptors may be affected. Assessment of these impacts was reserved until actual sites for the treatment facilities are proposed in site-wide or project-specific NEPA documents. Noise impacts due to transportation of waste to or from the treatment sites also was not evaluated in the Draft WM PEIS. Overall, though, less transportation would be conducted under this alternative because no waste would leave the treatment sites for disposal at WIPP. The transportation noise impacts, therefore, would be negligible.

There would be no impacts from truck or rail transportation to WIPP because waste transportation activities to WIPP would not be initiated.

5.5.6 Water Resources and Infrastructure

Water resource and infrastructure impacts at the treatment and storage sites under No Action Alternatives 1A and 1B would be the same as under Action Alternatives 2A and 2B (See Section 5.3.6). During decommissioning at WIPP, there would be a decreasing need and use of

water, power, and wastewater systems and a decreasing demand on-site transportation infrastructure. There would be no demand or use of these resources following decommissioning.

5.5.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for No Action Alternatives 1A and 1B are presented in the following subsections.

5.5.7.1 Life-Cycle Costs

Under No Action Alternatives 1A and 1B, WIPP would not receive waste. All waste volumes would remain indefinitely at the sites where treated. The CH-TRU waste portion of the waste inventory would be packaged every 20 years. Impacts from this packaging were evaluated over a 100-year period. No Action Alternatives 1A and 1B include the same waste treatment sites and the same waste volumes as those in Action Alternatives 2A and 2B. Cost for storage facilities are included with the cost of the treatment facilities. The WIPP site costs reflect a 10-year period of decommissioning. The waste transport costs reflect shipments between small sites and the treatment sites.

The transportation options include using trucks, regular rail, and dedicated rail services. Life-cycle costs for No Action Alternative 1A and 1B include additional costs of $700 million and $3.8 billion, respectively, to account for treatment to planning-basis WAC of waste to be shipped for treatment. These costs were based on dual treatment (WAC and thermal) of 34 percent and 18.4 percent, respectively, of the total waste volume. The total life-cycle cost of No Action Alternative 1A (shown in Table 5-74) vary slightly with mode of transportation: $28.2 billion ($16 billion when discounted) for truck, $28.2 billion ($15 billion when discounted) for regular-class rail service, and $28.4 billion ($16.1 billion when discounted) for dedicated-class rail service.

Table 5-74
Costs Under No Action Alternative 1A
(in millions of 1994 dollars)[a]

Life-Cycle Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	11,700	3,000	14,700	12,300	270	12,500	27,300	15,100
Transport by Truck	32	8	40	33	1	34	74	40
Transport by Regular Train	14	4	18	15	1	16	34	20
Transport by Dedicated Train	108	28	136	113	3	116	252	140
WIPP Decommissioning[b]	N/A	N/A	N/A	N/A	N/A	N/A	850	770
Total Life-Cycle Cost (Truck)	11,800	3,000	15,000	12,400	278	12,600	28,600	16,000
Total Life-Cycle Cost (Regular Rail)	11,700	3,000	14,700	12,300	270	12,500	28,600	15,900
Total Life-Cycle (Dedicated Rail)	11,800	3,000	14,800	12,400	270	12,600	28,800	16,100

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.
[b] The WIPP decommissioning cost of $850 million is applied to the total column only because it is not attributed to storage of CH-TRU or RH-TRU waste but must be considered in the life-cycle cost of the alternative.

The total life-cycle costs of No Action Alternative 1B (shown in Table 5-75) vary slightly depending on the mode of transportation, ranging from $31.5 billion ($18.0 billion when discounted) for regular-class rail service to $32.6 billion ($18.5 billion when discounted) for dedicated-class rail service.

Table 5-75
Costs Under No Action Alternative 1B
(in millions of 1994 dollars)[a]

Life-Cycle Cost Information	Basic Inventory			Additional Inventory			Total	Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment Facilities	13,100	3,400	16,500	13,700	305	14,000	27,700	17,100
Transport by Truck	101	26	127	106	2	108	235	130
Transport by Regular Train	68	17	85	71	2	73	158	90
Transport by Dedicated Train	509	130	639	533	12	545	1,200	670
WIPP Decommissioning	N/A	N/A	N/A	N/A	N/A	N/A	850	770
Total Life-Cycle Cost (Truck)	13,200	3,400	16,600	13,900	307	14,200	31,600	18,000
Total Life-Cycle Cost (Regular Rail)	13,200	3,400	16,600	13,800	307	14,100	31,500	18,000
Total Life-Cycle Cost (Dedicated Rail)	13,600	3,500	17,100	14,300	317	14,600	32,600	18,500

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.

5.5.7.2 Economic Impacts

TRU waste treatment activities would result in creation of additional direct, indirect, and induced jobs. Under No Action Alternative 1A approximately 15,700 jobs would be created in the ROIs of the six treatment sites (Hanford, INEL, LANL, ORNL, RFETS, and SRS). Under No Action Alternative 1B approximately 15,500 jobs would be created in the ROIs of four treatment sites (Hanford, INEL, ORNL, and SRS).

At WIPP, estimates of the impacts of No Action Alternative 1 on employment, income, and the production of goods and services within the ROI are presented in Table 5-76. These regional impacts are estimated on the basis of a constant declining operating budget over a 10-year decommissioning period (from 1998 to 2008). Over this 10-year period, direct employment at the WIPP facility would be reduced at an average annual rate of 10 percent, from 1,095 workers in 1998 to 0 workers in 2008. Accordingly, the WIPP site would employ about half its present work force by the year 2003. It is possible, however, that a more aggressive (front-loaded) downsizing could result in equivalent job losses within a two-year period, assuming an exponentially declining WIPP budget. The negative indirect impact from WIPP closure involves the eventual loss of an additional 2,300 jobs in the ROI work force. Overall, about 3,400 jobs would be lost in the WIPP ROI. The accompanying reduction in labor income and output of goods and services in the ROI would be $120 million ($97 million discounted) and $524 million ($423 million discounted), respectively.

Table 5-76
Economic Impacts Within the WIPP ROI Under No Action Alternative 1

Economic Effect	Job Loss (Full- and Part-Time Jobs)	Output of Goods & Services (millions of 1994 Dollars)	Labor Income (millions of 1994 Dollars)
Direct - Annual	-110	-19	-5
Indirect & Induced - Annual	-230	-34	-7
Total - Annual	-340	-52	-12
Total - Closure (10 years)	-3,340	-520	-120
Total - Closure (Discounted)	N/A	-420	-97

5.5.8 Transportation

The transportation impacts presented in this section for No Action Alternatives 1A and 1B were estimated by adjusting the impacts found for Action Alternatives 2A and 2B. For these analyses, the Action Alternative 2A and 2B impacts were adjusted to remove any impacts associated with the transportation to WIPP; only the impacts due to transporting the waste to the treatment sites were included. Details on the adjustment methods are included in Appendix E.

5.5.8.1 Route Characteristics and Shipment Projections

The number of shipments was estimated to be 562 and 5,173 CH-TRU waste shipments for No Action Alternatives 1A and 1B, respectively. The number of RH-TRU waste shipments were estimated to be 1,681 for both No Action Alternatives 1A and 1B. The methods used to estimate the number of shipments were the same as those presented in Section 5.1.8.1. The total estimated one-way mileage for consolidation of TRU waste under No Action Alternatives 1A and 1B is presented in Table 5-77.

Table 5-77
One-Way Waste Transportation Miles Under No Action Alternative 1

Alternative	CH-TRU Waste	RH-TRU Waste	Total
No Action Alternative 1A	300,000	1,100,000	1,400,000
No Action Alternative 1B	8,500,000	1,100,000	9,600,000

5.5.8.2 Accidents, Injuries, Fatalities, and Pollution-Related Health Effects

The population impacts for No Action Alternatives 1A and 1B are presented in Table 5-78. For No Action Alternative 1A, the total number of accidents, injuries, and fatalities over the entire shipping campaign were estimated to be 3, 0.1 and 0.1, respectively. Similarly, for No Action Alternative 1B, the accidents, injuries, and fatalities were estimated to be 14, 13, and 1.3, respectively. Also presented in Table 5-78, are the pollution-related health effects.

Table 5-78
Population Impacts from Truck Transportation Under No Action Alternative 1

Category	No Action Alternative 1A	No Action Alternative 1B
Nonradiological Impacts		
Number of Accidents	3	14
Number of Injuries	0.1	13
Number of Fatalities	0.1	1.3
Pollution Health Effects (fatalities)	5.0E-3	0.04
Accident-Free Radiological Impacts (LCFs)		
Occupational	5.2E-3	0.07
Nonoccupational		
Stops	0.09	0.5
Sharing Route	5.2E-3	0.03
Along Route	1.9E-3	0.01
Nonoccupational (LCFs) - Total	0.1	0.5
Aggregate Radiological Accident Impacts (LCFs)		
Total	6.0E-3	1.7E-2
Aggregate Radiological Population Impacts for Truck Transportation Accidents (LCFs)		
CH-TRU Waste	5.6E-3	0.02
RH-TRU Waste	1.2E-3	1.2E-3
Total CH-TRU and RH-TRU Waste	6.8E-3	0.02

5.5.8.3 Accident-Free Radiological Impacts from Truck Transportation

The method used to estimate accident-free radiological impacts for No Action Alternatives 1A and 1B were based on impacts reported for Action Alternatives 2A and 2B. However, because there are no shipments of TRU waste to WIPP under No Action Alternatives 1A and 1B, only the impacts under Action Alternatives 2A and 2B for the consolidation of waste at the treatment sites were included. Table 5-78 presents a summary of the accident-free radiological impacts for No Action Alternatives 1A and 1B.

5.5.8.4 Radiological Impacts from Truck Transportation Accidents

Two types of analyses were conducted for SEIS-II radiological impacts due to accidents. The first estimated impacts over the entire shipping campaign, and the second estimated impacts from four bounding case accidents. For the first analysis, the impacts were estimated based on the number of shipments and the eight accident severity categories presented in RADTRAN. For No Action Alternatives 1A and 1B, the radiological impacts from accidents summed over all shipments are presented in Table 5-78.

For the bounding case accidents, it was estimated that the impacts would be the same as those reported for truck transportation under the Proposed Action (see Section 5.1.8.4). The analyses were based on an assumption that only one TRUPACT-II or RH-72B would be breached in a bounding case accident. Though the waste would be treated thermally under No Action Alternatives 1A and 1B, the treatment would not occur until after the transportation.

5.5.8.5 Hazardous Chemical Impacts from Severe Truck Transportation Accidents

As reported previously in Section 5.1.8.5, exposures to hazardous chemical releases from a severe truck transportation accident would present negligible impacts to the exposed population.

5.5.8.6 Transportation Impacts Associated with Rail Shipments

Table 5-79 presents a summary of the transportation impacts for both regular and dedicated rail under No Action Alternatives 1A and 1B. The rail transportation impacts were estimated by adjusting the transportation impacts for truck shipments as described in Section 5.2.8.6 and Appendix E.

Table 5-79
Rail (Regular and Dedicated) Transportation Impacts Under No Action Alternative 1

Impact Category	No Action Alternative 1A	No Action Alternative 1B
Aggregate Traffic Related Fatalities		
Regular Rail	0.09	0.6
Dedicated Rail	2	16
Aggregate Accident-Free Impacts (LCFs)		
Occupational	3.2E-4	3.2E-3
Nonoccupational		
Stops	0.01	0.06
Sharing Route	5.0E-5	3.0E-4
Along Route	3.0E-3	0.02
Nonoccupational - Total	0.02	0.08
Aggregate Radiological Population Impacts for Rail Transportation Accidents (LCFs)		
CH-TRU Waste	5.6E-3	0.02
RH-TRU Waste	1.2E-3	1.2E-3
Total CH-TRU and RH-TRU Waste	6.8E-3	0.02

Radiological accident impacts from shipping by rail summed over all shipments for No Action Alternatives 1A and 1B are presented in Table 5-79 along with traffic-related fatalities and accident-free radiological impacts.

The impacts from bounding case accidents were estimated to be the same as those reported for Action Alternative 1 rail accident analyses. (Section 5.2.8.4) where it was assumed that two TRUPACT-IIs or RH-72Bs would be breached in an accident. The greatest impact was found when a conservative inventory was assumed, 32 LCFs to the population and a 12 percent chance of an LCF to the MEI.

5.5.9 Human Health Impacts from Waste Treatment and Storage Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from waste treatment and 100 years of managed storage under No Action Alternatives 1A and 1B. The estimates include the impacts from overpacking CH-TRU waste storage containers every 20 years. There would be no disposal of waste at WIPP under this alternative.

Impacts from waste treatment were adjusted from those presented in the Draft WM PEIS; a description of these adjustments is provided in Appendix B. Like Action Alternatives 2A and 2B, No Action Alternatives 1A and 1B include thermal treatment of the Total Inventory. The VOCs in the waste would be destroyed during thermal treatment, and hazardous metals would be immobilized. Therefore, no routine releases of hazardous chemicals would occur in the subsequent

waste storage operations. Thermal treatment also concentrates the waste and radionuclides into a smaller, denser volume. Denser waste matrices tend to decrease surface dose rates because of more self-absorption of the external radiation emitted by radionuclides in the waste. Worker radiological impacts reflect the impact of these factors. Appendix F provides additional information on the methods used to determine the impacts presented in this section.

5.5.9.1 Public

Impacts to the populations and to the MEIs under No Action Alternatives 1A and 1B are presented in this section; results are presented in Table 5-80. Impacts from waste treatment and managed storage operations are presented separately to show their relative impact contribution. Waste treatment and storage would take place at six DOE sites under No Action Alternative 1A and at four sites under No Action Alternative 1B. Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites and all lag storage sites. The impacts to the MEIs from waste treatment and managed storage operations are presented for the highest individual waste treatment and storage sites. See Chapter 3 for additional information on where treatment and managed storage would occur under the subalternatives of No Action Alternative 1.

Table 5-80
Lifetime Human Health Impacts to the Public from Waste Treatment and Storage Operations Under No Action Alternatives 1A and 1B

Category	Waste Treatment Impacts[a]		Storage Operations Impacts	
	Radiological (LCF)[b]	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemicals (Cancer Incidence)
MEI[c,d]				
Basic Inventory				
1A CH-TRU Waste	8E-5 (L)	6E-12	2E-7 (L)	0
1B CH-TRU Waste	2E-5 (S)	3E-12	5E-9 (S)	0
RH-TRU Waste	1E-6 (O)	6E-12	1E-9 (O)	0
1A Total Waste	8E-5 (L)	6E-12 (O)	2E-7 (L)	0
1B Total Waste	2E-5 (S)	6E-12 (O)	5E-9 (S)	0
Total Inventory				
1A CH-TRU Waste	9E-5 (L)	7E-12	2E-7 (L)	0
1B CH-TRU Waste	2E-5 (S)	7E-12	1E-9 (S)	0
RH-TRU Waste	1E-6 (O)	6E-12 (O)	2E-9 (O)	0
1A Total Waste	9E-5 (L)	7E-12 (O)	2E-7 (L)	0
1B Total Waste	2E-5 (S)	7E-12 (O)	2E-9 (O)	0
Population[c]				
Basic Inventory				
1A CH-TRU Waste	4.0	3E-7	7E-4	0
1B CH-TRU Waste	1.8	2E-7	4E-4	0
RH-TRU Waste	0.05	1E-7	3E-5	0
1A Total Waste	4.1	4E-7	7E-4	0
1B Total Waste	1.9	3E-7	4E-4	0
Total Inventory				
1A CH-TRU Waste	4.6	3E-7	1E-3	0
1B CH-TRU Waste	2.6	2E-7	6E-4	0
RH-TRU Waste	0.05	1E-7	5E-5	0
1A Total Waste	4.7	4E-7	1E-3	0
1B Total Waste	2.7	3E-7	7E-4	0

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring to the MEI, and the number of LCFs in the population.
[c] The MEI and populations evaluated for treatment and storage operations impacts are different.
[d] L=LANL, O=ORNL, S=SRS

Waste Treatment

Radiological impacts to the public from waste treatment would be 4.7 and 2.7 LCFs for No Action Alternatives 1A and 1B, respectively. No cancer incidence would be expected in the total population from hazardous chemical exposure, with 4 x 10^{-7} and 3 x 10^{-7} cancers expected for No Action Alternatives 1A and 1B, respectively. For radiological impacts the MEI would be at LANL for No Action Alternative 1A (9 x 10^{-3} percent chance of an LCF) and at SRS for No Action Alternative 1B (2 x 10^{-3} percent chance of an LCF). The specific CH-TRU waste sites for hazardous chemical impacts were not available, but impacts would not exceed about a 7 x 10^{-10} percent chance of a cancer incidence at any site. No noncarcinogenic health effects would occur because the maximum HIs for the MEI would be 2 x 10^{-8} (for No Action Alternative 1A) and 5 x 10^{-9} (for No Action Alternative 1B). No health effect is predicted unless the HI is 1 or higher.

Long-Term Managed Storage

Only radiological impacts would result from long-term managed storage because VOCs would be removed by thermal treatment under No Action Alternative 1. No LCFs would be expected in the total population around the storage sites under any of the alternatives, with 1 x 10^{-3} and 7 x 10^{-4} LCFs expected under No Action Alternatives 1A and 1B, respectively. The MEI would be at LANL for No Action Alternative 1A (2 x 10^{-5} percent chance of an LCF) and at ORNL for No Action Alternative 1B (2 x 10^{-7} percent chance of an LCF). No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

5.5.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under No Action Alternatives 1A and 1B are presented in this section; results are presented in Table 5-81. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, storage, or handling of waste. Impacts from waste treatment and long-term managed storage are presented separately to show the relative contributions of these activities.

Noninvolved worker population impacts were estimated as the total for all treatment sites and all managed storage facilities. The impacts to the maximally exposed noninvolved worker from waste treatment and managed storage are presented for the highest individual waste treatment sites.

Waste Treatment

No radiation-related LCFs would be expected in the total noninvolved worker population at the waste treatment sites, with 0.5 and 0.3 LCFs under Action Alternatives 1A and 1B, respectively. No cancer incidence would be expected in the total noninvolved worker population from hazardous chemical exposure, with 1 x 10^{-7} cancers for both of the subalternatives. The maximally exposed noninvolved worker for radiological impacts would be at LANL for No Action Alternative 1A (3 x 10^{-2} percent chance of an LCF) and at SRS for No Action Alternative 1B (2 x 10^{-2} percent chance of an LCF). Impacts would not exceed a 1 x 10^{-8} percent chance of a cancer incidence at any site. No noncarcinogenic health effects would occur because the maximum HIs for the maximally exposed noninvolved worker would be 2 x 10^{-7} (for No Action Alternative 1A) and 1 x 10^{-7} (for No Action Alternative 1B). No health effect is predicted unless the HI is 1 or higher.

Long-Term Managed Storage

Only radiological impacts would result from the 100 years of managed storage because VOCs would be removed by thermal treatment. No LCFs would be expected in the total noninvolved

Table 5-81
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment and Storage Operations Under No Action Alternative 1

Category	Waste Treatment Impacts[a]		Storage Operations Impacts	
	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)
Maximally Exposed Noninvolved Worker[c,d]				
Basic Inventory				
1A CH-TRU Waste	3E-4 (L)	2E-11	8E-7 (S)	0
1B CH-TRU Waste	2E-4 (S)	1E-11	8E-7 (S)	0
RH-TRU Waste	1E-6 (O)	4E-11	1E-8 (O)	0
1A Total Waste	3E-4 (L)	4E-11 (O)	8E-7 (S)	0
1B Total Waste	2E-4 (S)	4E-11 (O)	8E-7 (S)	0
Total Inventory				
1A CH-TRU Waste	3E-4 (L)	2E-11	1E-6 (S)	0
1B CH-TRU Waste	2E-4 (S)	2E-11	1E-6 (S)	0
RH-TRU Waste	1E-6 (O)	4E-11	2E-8 (O)	0
1A Total Waste	3E-4 (L)	4E-11 (O)	1E-6 (S)	0
1B Total Waste	2E-4 (S)	4E-11 (O)	1E-6 (S)	0
Population[c]				
Basic Inventory				
1A CH-TRU Waste	0.4	7E-8	0.02	0
1B CH-TRU Waste	0.2	4E-8	-0.02	0
RH-TRU Waste	2E-3	4E-8	-2E-4	0
1A Total Waste	0.4	1E-7	0.02	0
1B Total Waste	0.2	1E-7	0.02	0
Total Inventory				
1A CH-TRU Waste	0.5	8E-8	0.02	0
1B CH-TRU Waste	0.3	6E-8	-0.02	0
RH-TRU Waste	2E-3	4E-8	-2E-4	0
1A Total Waste	0.5	1E-7	0.02	0
1B Total Waste	0.3	1E-7	0.02	0

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring to the maximally exposed noninvolved worker, and the number of LCFs in the population.
[c] The MEI and populations evaluated for treatment and storage operations impacts are different.
[d] L = LANL, O = ORNL, S = SRS

worker population at the managed storage sites (0.02 LCFs would be expected under both subalternatives). The maximally exposed noninvolved worker would be at SRS for both subalternatives; a 1 x 10^{-4} percent chance of an LCF was calculated. No noncarcinogenic health effects would occur because there would be no exposure to hazardous chemicals.

5.5.9.3 Involved Workers

Potential impacts to involved workers from waste treatment and storage operations are presented in Table 5-82. Up to 5 LCFs could occur in involved worker populations from radiation exposure during waste treatment under either No Action Alternatives 1A or 1B. No cancer incidence would be expected to occur from hazardous chemical exposure (2 x 10^{-4} cancers for No Action Alternative 1A and 3 x 10^{-4} cancers for No Action Alternative 1B), and no noncarcinogenic health effects would occur (maximum exposure index of 6 x 10^{-3}).

No impacts from radiation exposure would be expected from waste storage during the 100-year storage period evaluated (≤0.4 LCF) under either subalternative. All worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-82
Lifetime Human Health Impacts to Involved Workers from Waste Treatment and Storage Operations Under No Action Alternative 1[a]

Category	Waste Treatment Impacts[b]		Storage Operations Impacts	
	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)	Radiological (LCF)	Hazardous Chemicals (Cancer Incidence)
Population				
Basic Inventory				
1A CH-TRU Waste	2.1	9E-5	0.09	0
1B CH-TRU Waste	2.1	1E-4	0.08	0
RH-TRU Waste	0.2	1E-5	≤0.09	0
1A Total Waste	2.3	1E-4	≤0.2	0
1B Total Waste	2.3	1E-4	≤0.2	0
Total Inventory				
1A CH-TRU Waste	4.4	2E-4	0.2	0
1B CH-TRU Waste	4.6	3E-4	0.2	0
RH-TRU Waste	0.2	1E-5	≤0.2	0
1A Total Waste	4.6	2E-4	≤0.4	0
1B Total Waste	4.8	3E-4	≤0.4	0

[a] The workers considered for treatment impacts and storage impacts are different.
[b] Adapted from the Draft WM PEIS (DOE 1995f).

Different populations of involved workers would be involved in routine surveillance and monitoring activities and in waste overpacking operations. All sites were assumed to overpack 5 percent of the CH-TRU waste Total Inventory annually during the 100 years of storage evaluated. Each CH-TRU waste container would be overpacked every 20 years, although if this alternative were selected the Department would probably begin efforts to design longer lasting CH-TRU waste containers.

The impacts from CH-TRU waste would be from the external radiation dose received during waste container handling. Potential radiological impacts from inhalation of radioactive gases released from waste containers would be negligible. Involved worker impacts from storage activities were calculated by assuming waste handlers would spend 2 hours every workday at 1 meter (3.3 feet) from the CH-TRU waste containers and were assumed to be exposed over a 35-year career. Container dose rates were decay-corrected over 35 years. The first 35 years of packaging operations would be the period of greatest potential impact because radioactive decay would reduce the radioactivity of the waste over time. Table 5-83 shows how potential annual radiological impacts to involved worker populations would decrease over the storage period because of radioactive decay.

Overpacking of RH-TRU waste containers was not considered during the 100-year storage period because of the greater RH-TRU waste container integrity. Impacts from RH-TRU waste storage would be less because of remote RH-TRU waste handling and greater administrative controls for RH-TRU waste. Therefore, no specific RH-TRU waste storage impact estimates were made. Storage impacts under this alternative would be assessed in future site-wide or project-specific NEPA reviews.

Table 5-83
Annual Involved Worker Population Impacts from CH-TRU Waste Overpacking Operations Under No Action Alternatives 1A and 1B (LCFs)

Location	Worker Population	Years Since Operations Began					
		1	20	40	60	80	100
No Action Alternative 1A							
Hanford	14	9E-3	6E-3	4E-3	3E-3	2E-3	1E-3
INEL	14	4E-3	3E-3	3E-3	3E-3	3E-3	3E-3
LANL	4	6E-4	6E-4	5E-4	5E-4	4E-4	4E-4
RFETS	1	3E-3	3E-3	2E-3	2E-3	2E-3	2E-3
SRS	2	1E-4	1E-4	1E-4	1E-4	9E-5	9E-5
No Action Alternative 1B							
Hanford	14	9E-3	6E-3	4E-3	3E-3	2E-3	1E-3
INEL	19	7E-3	7E-3	6E-3	6E-3	6E-3	6E-3
SRS	2	1E-4	1E-4	1E-4	1E-4	9E-5	9E-5

5.5.10 Facility Accidents

This section describes potential impacts of facility accidents at the treatment sites from thermal treatment of waste and from indefinite waste storage after treatment under No Action Alternatives 1A and 1B. The difference between No Action Alternatives 1A and 1B is that no CH-TRU waste would be treated or stored at LANL and RFETS under No Action Alternative 1B.

No waste would be disposed of under the two No Action Alternative 1 subalternatives; therefore, no WIPP disposal accidents were analyzed.

5.5.10.1 Waste Treatment Accidents

The impacts of waste treatment accidents under both No Action Alternative 1 subalternatives would be the same as those under Action Alternatives 2A and 2B (see Section 5.3.10.1). In both cases, the waste would be treated thermally at the same sites.

5.5.10.2 Waste Storage Accidents

Potential facility accident impacts under both No Action Alternative 1 subalternatives would be very similar to those presented in Section 5.3.10.2 for Action Alternatives 2A and 2B because stored waste would have been thermally treated. Because WIPP would not be an indefinite storage site under either No Action Alternative 1 subalternative some of the maximum values reported for the MEI in Section 5.3.10.2 would change. These differences are as follows:

- The maximum radiological impacts to the MEI from the drum puncture accident (Accident Scenario S1) would occur at LANL with an 8×10^{-7} percent chance of an LCF. Maximum impacts from the earthquake (Accident Scenario S3) would also be at LANL, with a 0.3 percent chance of an LCF.

- The maximum hazardous metal carcinogenic impacts to the MEI from the drum puncture accident (Accident Scenario S1) would occur at LANL, with a 1×10^{-14} percent chance of cancer. The maximum hazardous metal carcinogenic impacts to the MEI from the earthquake (Accident Scenario S3) would occur at Hanford, with a 5×10^{-8} percent chance of cancer.

Additional accident analysis information is presented in Appendix G.

As waste would be maintained in storage over long periods of time, the accident risk would be expected to change. Radioactive decay would reduce the amount of radioactivity in the waste. Impacts from a drum puncture (Accident Scenario S1) would be expected to decrease because of reduced radioactivity and overpacking reducing the potential amount of particulates spilled from the waste container in the event of a breach. Impacts from an earthquake (Accident Scenario S3) may decrease because of overpacking or may remain stable because of deterioration of the waste form over time. The deterioration may result in an increase in the amount of particulates released in the event that containers are breached.

5.5.11 Industrial Safety

Nine and seven fatalities would occur from industrial accidents during waste treatment at all treatment sites under No Action Alternatives 1A and 1B, respectively. These estimates were adjusted from the physical-hazard fatality estimates of the Draft WM PEIS.

Under No Action Alternatives 1A and 1B, industrial safety impacts could occur as a result of decommissioning the WIPP site and from constructing and operating long-term TRU waste storage facilities at the treatment sites. Results are presented in Table 5-84. WIPP decommissioning activities would be the same as those discussed under the Proposed Action, except that activities would begin in 1998. In all likelihood, the initial work force would be smaller and the decommissioning period shorter, resulting in fewer injuries and illnesses. No fatalities would be projected.

Table 5-84
Industrial Safety Impacts from WIPP Decommissioning and Site Storage Under No Action Alternative 1

Years	Injury/Illness			Fatalities		
	Construction	Operations	Total	Construction	Operations	Total
WIPP Decommissioning 1998-2008	187	96	283	0.3	0.1	0.4
Indefinite Storage at Sites (packaging and monitoring for 100-year period)	124	213	337	0.2	0.2	0.4

Long-term storage impacts were evaluated for a 100-year period. It was assumed that CH-TRU waste storage facilities would be constructed. Waste would be moved to new facilities every 50 years. RH-TRU waste storage facilities would necessarily be more robust to provide the required shielding and would be constructed only once during the period and would last 100 years. CH-TRU waste would be repackaged every 20 years (5 percent per year), while RH-TRU waste, stored in drums inside welded steel canisters, would not be repackaged during the 100-year period. Each year approximately 20 percent of the CH-TRU waste and 5 percent of the RH-TRU waste would be monitored in a manner requiring worker attention to individual containers (e.g., smearing the exterior of containers for contamination and checking lid seals or welds). These activities would be accomplished remotely for RH-TRU waste. No fatalities would occur during the 100-year storage period.

5.5.12 Long-Term Post-Closure Performance

Under No Action Alternatives 1A and 1B, TRU waste would not be shipped to WIPP. WIPP would be decommissioned or put to other uses as appropriate. TRU waste would continue to be

generated and put into monitored, retrievable storage. No long-term radiological or hazardous chemical impacts to the environment or human health would occur at the WIPP site.

At the storage sites under this alternative, it was assumed that DOE would provide effective monitoring and maintenance of storage facilities. As a consequence, adverse health effects for the general public while DOE maintained control would be minimal, and the principal adverse effects, which also would be small, would be related to occupational activity at the facility. Health effects would continue at such levels for the indefinite future under the hypothesis of DOE control. It also was assumed that DOE would indefinitely maintain institutional control, and, therefore, long-term impacts of post-closure intruder and environmental release impacts were not assessed.

While it was assumed for purposes of this analysis that institutional control would be maintained indefinitely by the Department, loss of institutional control is always a possibility under this alternative. If control were lost, health impacts would be realized from acute and chronic human exposure resulting from inadvertent intrusion and from long-term releases of waste into site-specific environmental settings. However, the thermal treatment process used in No Action Alternative 1 would affect these impacts in a number of ways.

Radionuclides and hazardous metals would be incorporated into a more dense and durable waste form that would limit the release of waste into the accessible environment. VOCs would be removed in the treatment process and would not be present in emplaced waste. Once waste containers degrade, direct release from a thermally-treated waste form (e.g., metal slag or glass) would be controlled by corrosion and dissolution of metal or glass and natural forces responsible for erosion rather than the leaching process that controls radionuclide and metal contaminant releases from less competent waste forms. Aggregate impacts of long-term environmental release would probably be more than one but less that the 2,325 LCFs reported for No Action Alternative 2 in Section 5.6.12. Like No Action Alternative 2, this range of estimates is based on current population distributions. Substantial changes, with populations moving onto the sites and near storage facilities, could result in considerably higher impacts. Thermal treatment would also result in more concentrated levels of radionuclides and metals so that direct radiation dose and impacts from intrusion could be higher than those from the untreated waste evaluated under No Action Alternative 2.

5.6 IMPACTS OF NO ACTION ALTERNATIVE 2

This section describes the environmental impacts associated with the implementation of No Action Alternative 2. If No Action Alternative 2 were implemented, WIPP would be closed, newly generated waste would be treated to planning-basis WAC, all other waste would be left as is, and all of the waste would remain at the sites where it is currently located or would be generated. A detailed description of No Action Alternative 2 is presented in Section 3.2.6.

5.6.1 Land Use and Management

Construction of treatment facilities under this alternative would be minimal. Only newly generated waste would be treated. All other waste would continue to be stored as it has been to date. Therefore, minimal land use impacts would be expected.

At WIPP, land use impacts under No Action Alternative 2 would be similar to those for WIPP under No Action Alternative 1, discussed in Section 5.5.1.

5.6.2 Air Quality

Very limited treatment would be done under No Action Alternative 2. Only newly generated waste would be treated. All other waste would be left as it has been stored to date. Also, any treatment conducted would be to planning-basis WAC; no thermal or shred and grout treatment would be conducted. Air quality impacts due to treatment, therefore, would be very minimal. At WIPP, potential air quality impacts due to decommissioning activities under No Action Alternative 2 would be similar to those under No Action Alternative 1 described in Section 5.5.2.

5.6.3 Biological Resources

Because very limited treatment would be done under No Action Alternative 2 and because current storage facilities would be used, minimal biological impacts would be expected due to construction and operation of treatment and storage facilities. Potential impacts on biological resources at WIPP under No Action Alternative 2 would be similar to those under No Action Alternatives 1A and 1B, described in Section 5.5.3.

5.6.4 Cultural Resources

Because very limited treatment would be done under this alternative, minimal cultural resource impacts, if any, would be expected. Also, no potential cultural resources impacts at WIPP would be expected under this alternative.

5.6.5 Noise

Potential noise impacts under No Action Alternative 2 would be negligible. No waste would be transported and only newly generated waste would be treated.

5.6.6 Water Resources and Infrastructure

Under No Action Alternative 2 there would be minimal incremental infrastructure impacts from water, wastewater, and power usage due to treatment to planning-basis WAC and storage. During decommissioning at WIPP, there would be a decreasing need and use of water, power, and wastewater systems and on-site transportation infrastructure. There would be no demand or use of these resources following decommissioning.

5.6.7 Socioeconomics

Estimated life-cycle costs and potential socioeconomic impacts for No Action Alternative 2 are presented in the following subsections.

5.6.7.1 Life-Cycle Costs

The life-cycle costs of No Action Alternative 2 are reported in Table 5-85. Under No Action Alternative 2, WIPP would not be used as a waste disposal site. Closure of the WIPP site would follow a 10-year period of decommissioning, beginning in 1998 and ending in 2008. There would be no waste transportation under No Action Alternative 2. Waste generator sites would treat and store CH-TRU and RH-TRU waste inventories for 35 years. Waste treatment operations at these sites cover only newly generated waste. Current waste management practices would continue. The total life-cycle costs of the No Action Alternative 2 would be $2.7 billion ($1.8 billion when discounted), reflecting life-cycle costs at the treatment sites and decommissioning costs at the WIPP site.

Table 5-85
Life-Cycle Costs Under No Action Alternative 2
(in millions of 1994 dollars)[a]

Cost Information	Basic Inventory			Total Discounted
	CH-TRU Waste	RH-TRU Waste	CH-TRU and RH-TRU Waste	CH-TRU and RH-TRU Waste
Treatment of Newly Generated Waste	671	37	708	390
Storage of all Waste	802	354	1,200	670
WIPP Decommissioning[b]	N/A	N/A	850	770
Total Life-Cycle Cost	1,500	391	2,700	1,800

[a] The methods and assumptions used to estimate the various cost components are described in Appendix D. Actual totals may differ due to rounding.
[b] The WIPP decommissioning cost of $850 million is applied to the total column only because it is not attributed to either CH-TRU or RH-TRU waste at the storage sites but must be considered in the life-cycle cost of this alternative.

5.6.7.2 Economic Impacts

TRU waste treatment activities would result in creation of additional direct, indirect, and induced jobs. Under No Action Alternative 2, only the newly generated defense waste would be treated, and approximately 800 jobs would be created throughout the ROIs of the ten major generator sites (ANL-E, Hanford, INEL, LANL, LLNL, Mound, NTS, ORNL, RFETS, and SRS).

The economic impacts at the WIPP site would be the same as those for No Action Alternatives 1A and 1B, presented in Section 5.5.7.2.

5.6.8 Transportation

No waste would be transported under No Action Alternative 2, so there would be no transportation impacts.

5.6.9 Human Health Impacts from Waste Treatment and Management Operations

This section presents human health impacts to the public, noninvolved workers, and involved workers from treatment of newly generated TRU waste to meet the planning-basis WAC and from continuation of current waste management practices (aboveground waste storage) under No Action Alternative 2. There would be no disposal of waste at WIPP under this alternative. Impacts from waste treatment were adjusted from those presented in the Draft WM PEIS. A description of these adjustments is provided in Appendix B.

5.6.9.1 Public

Impacts to the populations and to the MEIs under No Action Alternative 2 are presented in this section; results are presented in Table 5-86. Impacts from treatment of newly generated waste and continued waste management/storage operations are presented separately to show their relative contribution to the total impact. Waste treatment and management/storage would take place at multiple DOE sites. Population impacts were estimated for those members of the public residing within 80 kilometers (50 miles) of all treatment sites and all management/storage sites. The impacts to the MEIs from waste treatment and waste management/storage operations are presented for the highest individual sites. See Chapter 3 for additional information on where treatment and management/storage would occur under No Action Alternative 2.

Table 5-86
Lifetime Human Health Impacts to the Public from Waste Treatment and Storage Operations Under No Action Alternative 2

Category	Waste Treatment Impacts[a]		Storage Operations Impacts	
	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)
MEI[c,d]				
Basic Inventory				
CH-TRU Waste	9E-9 (L)	4E-12	2E-6 (O)	4E-8 (L)
RH-TRU Waste	9E-11 (H)	8E-12 (O)	2E-9 (O)	2E-8 (O)
Total Waste	9E-9 (L)	8E-12 (O)	2E-6 (O)	4E-8 (L)
Population[c]				
Basic Inventory				
CH-TRU Waste	2 E-4	2 E-7	1E-2	2E-3
RH-TRU Waste	5 E-6	2 E-7	3E-5	3E-4
Total Waste	2E-4	4E-7	1E-2	2E-3

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring to the MEI, and the number of LCFs in the population.
[c] The MEI and populations considered for treatment impacts and storage impacts are different.
[d] H = Hanford, L = LANL, O = ORNL,

Waste Treatment

No LCFs would be expected in the total population around the waste treatment sites (2×10^{-4} LCF); no cancer incidence (4×10^{-7} cancers) would be expected in the total population from hazardous chemical exposure. The MEI would be at LANL for radiological impacts (9×10^{-7} percent chance of an LCF) and at ORNL for hazardous chemical impacts (8×10^{-10} percent chance of a cancer incidence). No noncarcinogenic health effects would occur. The maximum HI for the MEI would be 8×10^{-11}. No health effect is predicted unless the HI is 1 or higher.

Continued Management/Storage

No LCFs would be expected in the total population around the lag storage sites (1×10^{-2} LCF); no cancer incidence (2×10^{-3} cancers) would be expected in the total population from hazardous chemical exposure. The MEI would be at ORNL for radiological impacts (2×10^{-4} percent chance of an LCF) and at LANL for hazardous chemical impacts (4×10^{-6} percent chance of a cancer incidence). No noncarcinogenic health effects would occur. The maximum HI for any MEI would be 4×10^{-4}.

5.6.9.2 Noninvolved Workers

Impacts to the noninvolved worker population and the maximally exposed noninvolved worker under No Action Alternative 2 are presented in this section; results are presented in Table 5-87. A noninvolved worker is an employee who works at a site but is not directly involved in the treatment, management, or storage of waste. Impacts from waste treatment and management/ storage are presented separately to show the relative impact contribution of these activities. Waste treatment and management/storage would take place at multiple DOE sites. Noninvolved worker population impacts were estimated as the total for all treatment sites and all management/storage sites. The impacts to the maximally exposed noninvolved worker from waste treatment and management/storage are presented for the highest individual waste treatment sites.

Table 5-87
Lifetime Human Health Impacts to Noninvolved Workers from Waste Treatment and Storage Operations Under No Action Alternative 2

Category	Waste Treatment Impacts[a]		Storage Operations Impacts	
	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)	Radiological (LCF)[b]	Hazardous Chemical (Cancer Incidence)
Maximally Exposed Noninvolved Worker[c, d]				
Basic Inventory				
CH-TRU Waste	7E-9 (L)	1E-11	8E-6 (O)	2E-7 (I)
RH-TRU Waste	3E-10 (H)	5E-11	3E-5 (O)	3E-8 (H)
Total Waste	7E-9 (L)	5E-11 (O)	4E-5 (O)	2E-7 (I)
Population[c]				
Basic Inventory				
CH-TRU Waste	2E-5	5E-8	4E-2	4E-3
RH-TRU Waste	2E-7	5E-8	8E-5	5E-4
Total Waste	2E-5	1E-7	4E-2	2E-3

[a] Adapted from the Draft WM PEIS (DOE 1995f).
[b] The probability of an LCF occurring to the maximally exposed noninvolved worker, and the number of LCFs in the population.
[c] The noninvolved workers considered for treatment impacts and operations impacts are different.
[d] H = Hanford, I = INEL, L = LANL, O = ORNL

Waste Treatment

No LCFs would be expected in the total noninvolved worker population at the waste treatment sites (2×10^{-5} LCF); no cancer incidence (1×10^{-7} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at LANL for radiological impacts (7×10^{-7} percent chance of an LCF) and at ORNL for hazardous chemical impacts (5×10^{-9} percent chance of a cancer incidence). No noncarcinogenic health effects would occur because the maximum HI for the maximally exposed noninvolved worker would be 8×10^{-10}. No health effect is predicted unless the HI is 1 or higher.

Continued Management/Storage

No LCFs would be expected in the total noninvolved worker population at the management/storage sites (4×10^{-2} LCF); no cancer incidence (2×10^{-3} cancers) would be expected in the total noninvolved worker population from hazardous chemical exposure. The maximally exposed noninvolved worker would be at ORNL for radiological impacts (4×10^{-3} percent chance of an LCF) and at INEL for hazardous chemical impacts (2×10^{-5} percent chance of a cancer incidence). No noncarcinogenic health effects would occur; the maximum HI for any maximally exposed noninvolved worker would be 1×10^{-3}.

5.6.9.3 Involved Workers

Potential impacts to involved workers from treatment of newly generated waste and storage operations under No Action Alternative 2 are presented in Table 5-88. No LCFs (0.08) would occur in the total involved worker population from radiation exposure during waste treatment. No cancer incidence (4×10^{-6} cancers) would be expected from hazardous chemical exposure, and no noncarcinogenic health effects would occur (maximum exposure index of 5×10^{-5}). Less than 1 radiation-related LCF, and less than 0.04 cancers from hazardous chemical exposure would be expected in the involved worker population from continued waste management and storage operations. All worker exposures to radiation and hazardous chemicals would be controlled to ALARA levels. Administrative controls such as worker and area monitoring, rotation of workers to reduce exposures, and standard operating procedures would be used to limit exposures.

Table 5-88

Customer Focus and Satisfaction

Customer Expectations

The organization seeks to understand customers' needs and expectations.

Customer Service Standards

The organization has customer service standards and measures customer satisfaction in order to understand customer needs and expectations.

Customer Relationship Management

The organization builds relationships with customers, and uses the information to improve those relationships as well as processes and services.

Determining Customer Satisfaction

The organization measures customer satisfaction (and dissatisfaction) and compares its results to those of other organizations.

Customer Satisfaction Results

Not understood	To some extent	Understand	Cannot function without understanding	Not built	lead to some improvements	relationships lead to regular improvements	without them	Not determined	A few measures	Many	Used continuously	Doesn't measure satisfaction	satisfaction but makes no comparisons	Makes comparisons with other service providers	Consistently outperforms most	0%	50%	100%

[1] Adapted from the Draft WM PEIS (DOE 1995f).

This section provides a summary of long-term impacts from stored TRU waste at the major generator-storage sites for 10,000 years following the loss of institutional control. The analysis of human health impacts estimated the impacts of TRU waste as a source of direct exposure and as a contaminant source for release to surface and subsurface exposure points in the environment. Scenarios analyzed included exposure to waterborne and airborne releases of contaminants from waste stored in shallow earth-covered trenches or covered by earthen berms and to waste stored in exposed surface pads or in surface enclosures and buildings.

The impacts to human health from waste intrusion and long-term environmental release were estimated using methods outlined in Appendix I and in a technical supporting document (Buck et al. 1996). This analysis focused on the impacts of waste at seven of the 10 major sites because the majority (99 percent) of the waste is stored at these sites. Estimates for RH-TRU waste impacts were only made at sites storing RH-TRU waste which are Hanford, INEL, LANL, and ORNL. For buried waste, no estimates of impacts were made for either CH-TRU or RH-TRU waste at LLNL and RFETS because neither of these sites currently store waste in buried configurations.

Exposure scenarios evaluated include acute and chronic on-site intruder scenarios and chronic on-site and off-site MEI and population exposures. Intrusion exposure scenarios included the following:

- A drilling/gardener intruder
- A scavenger intruder

Chronic long-term exposure scenarios included the following:

- A family farm scenario
- An off-site population scenario

Descriptions of these scenarios, as applied to this analysis, are provided in Appendix I.

Impacts from Intrusion into Waste

The following sections describe the radiological and hazardous chemical impacts to postulated intruders for buried and surface-stored waste.

Buried Waste Storage

With the loss of institutional control, an inadvertent intruder could come into contact or become directly exposed to waste stored in shallow burial storage facilities by drilling into the waste. A drilling intruder scenario postulates an individual who would drill into the waste and become exposed to waste material brought to the land surface by the drilling process. Another indirect exposure from this scenario would be an intruder gardener scenario which assumes that an individual would be directly exposed to waste material brought to the land surface by the drilling. The individual would farm in soil contaminated by the waste materials and would ingest contaminated materials and eat produce from the garden. To bound the impact, calculations assumed the intrusions occurred at loss of institutional control. Analyses performed for both CH-TRU and RH-TRU waste are summarized below.

Radiological impacts to a hypothetical driller exposed acutely for 5 days (1 work week) from CH-TRU waste would range from 2 x 10^{-3} to 9 x 10^{-3} percent chance of an LCF for the five sites with buried CH-TRU waste. Impacts to the driller from RH-TRU waste would range from 7 x 10^{-4} to 4 x 10^{-2} percent chance of an LCF for the four sites with buried RH-TRU waste. Sites with the highest impacts would be SRS for CH-TRU waste and Hanford for RH-TRU waste. These results are presented in Table 5-90. Health impacts from hazardous chemicals would be negligible compared to the radiological impacts.

Radiological impacts to a hypothetical gardener exposed chronically from 30 years of gardening would range from a 1 to 6 percent chance of an LCF for the five sites with buried CH-TRU waste. Impacts to the gardener from RH-TRU waste would range from a 0.4 to 7 percent chance of an LCF for the four sites with buried RH-TRU waste. Sites with the highest impacts would be SRS for CH-TRU waste and Hanford for RH-TRU waste. These results are also presented in Table 5-90. Again, health impacts from hazardous chemicals would be negligible compared to the radiological impacts.

Table 5-90
Radiological Impacts to Inadvertent Intruders Following Loss of Institutional Control for Seven Major Generator-Storage Sites (probability of an LCF)

	Hanford	INEL	LLNL	LANL	ORNL	RFETS	SRS
CH-TRU Waste Impacts							
Buried Waste							
Driller (acute)	1.5E-05	7.1E-05	N/A	3.0E-05	7.0E-05	N/A	9.0E-05
Gardener (chronic)	9.7E-3	0.01	N/A	0.02	0.02	N/A	0.06
Surface Waste							
Scavenger (acute)	1.6E-03	2.1E-03	6.4E-04	3.3E-03	2.6E-03	0.02	0.01
Family Farm (chronic)	>1	>1	>1	>1	>1	>1	>1
RH-TRU Waste Impacts							
Buried Waste							
Driller (acute)	3.8E-04	6.5E-05	N/A	6.6E-06	4.6E-05	N/A	N/A
Gardener (chronic)	0.07	0.02	N/A	4.0E-03	0.02	N/A	N/A
Surface Waste							
Scavenger (acute)	0.01	2.1E-03	N/A	6.9E-04	1.4E-03	N/A	N/A
Family Farm (chronic)	>1	>1	N/A	>1	>1	N/A	N/A

Surface-Stored Waste

With loss of institutional control, inadvertent intruders may come into more direct contact and be directly exposed to waste in surface storage facilities. To estimate this impact, exposure calculations were performed for a hypothetical scavenger intruder assumed to come into direct contact with the surface-stored waste during a 24-hour period after loss of institutional control. The scavenger was assumed to be exposed via inhalation of resuspended contamination, external and inadvertent ingestion of contaminated soil while at the site.

Radiological impacts to a hypothetical scavenger from CH-TRU waste would range from a 0.2 to 2 percent chance of an LCF; all seven sites would have surface-stored CH-TRU waste. Impacts to the scavenger from RH-TRU waste would range from a 7 x 10^{-2} to 1 percent chance of an LCF for the four sites with buried RH-TRU waste. Sites with the highest impacts would be RFETS for CH-TRU waste and Hanford for RH-TRU waste. These results are presented in Table 5-71. Health impacts from hazardous chemicals would be negligible compared to the radiological impacts.

Another potential intruder scenario for surface-stored waste examined was a hypothetical family that lives and farms on a plot of land immediately over the surface-stored waste once the waste degrades to the point where it becomes indistinguishable from the surrounding land. For these conditions, the maximally exposed intruder in the family could be exposed via ingestion of contaminated food crops grown in the contaminated soil, inhalation of resuspended contamination, external exposure to the soil, and inadvertent ingestion of contaminated soil. If this scenario ever occurred, the four-member farm family would probably receive severe and potentially lethal doses over the 30-year exposure period. Radiological impacts to the MEI from CH-TRU waste would be an almost certain cancer fatality or other lethal radiation effects at all seven sites with surface-stored waste. Impact to the MEI from RH-TRU waste would also be an almost certain cancer fatality or other lethal radiation effects at all four sites with surface-stored waste. These results are presented in Table 5-90. Health impacts from hazardous chemicals would be negligible compared to the radiological impacts.

Impacts of Long-Term Environmental Release

Contaminants in TRU waste stored in shallow burial trenches and surface storage facilities within site-specific environmental settings (See Chapter 4) would eventually be released to the surrounding environments at the treatment sites. Contaminants within the buried or surface-stored waste would be leached and released to underlying soils and aquifer systems at depth. Eventually, at most sites, contaminants would reach groundwater and migrate laterally to a downgradient receptor location. Contaminants may also eventually be discharged into nearby surface water bodies. Once in these surface-water systems, dilute concentrations of the contaminants would become available to public water intakes for nearby communities.

Waste stored in surface facilities would also degrade and become available in the environment by the processes of direct water and air erosion, deposition onto soils surrounding the site, and resuspension of contaminated soils in air. The general surrounding on-site and off-site population would be exposed to these contaminants as they redistributed into the environment by these cyclic and ongoing processes.

For this analysis, the impacts to a hypothetical family farm of two adults and two children that would live 300 meters (980 feet) downgradient of the waste storage area was estimated. It was assumed that the family would engage in farming activities such as growing and consuming its own crops and livestock. The family would use contaminated groundwater as a source of drinking water and for watering the crops and animals. The MEI would be exposed via ingestion of contaminated food crops grown in the contaminated soil, inhalation of resuspended contamination, external exposure to the soil, and inadvertent ingestion of contaminated soil.

This analysis also considered the off-site population who could potentially be exposed to environmental releases to surface water and to air. For analyses of buried waste releases, all CH-TRU and RH-TRU waste was combined into a single waste disposal unit, and only the groundwater pathway was considered. For analyses of surface-stored waste releases, all CH-TRU and RH-TRU waste were combined into a single waste storage unit and were allowed to be released to all pathways.

Impacts to the MEIs were estimated for 70-year lifetimes over the 10,000 years of environmental release of contaminants from buried and surface-stored waste at the seven major generator-storage sites. The maximum MEI lifetime impacts over this period are presented in Table 5-91. Depending upon the site, the pathway, and the impact measure, the time of maximum impact could begin from 35 to 7,000 years after the loss of institutional control. Overall, maximum radiological impacts would occur before maximum hazardous chemical impacts. Radiological impacts would

Table 5-91
Maximum Lifetime MEI and Population Impacts for Seven Major Generator-Storage Sites

Major Sites	Radiological Impacts		Chemical Carcinogenic Impacts	
	Lifetime LCF[a]	Dominant Pathway	Lifetime Cancer Incidence	Dominant Pathway
MEI Impacts				
Hanford	8.5E-4	Inhalation	1.0E-4	Groundwater Ingestion
INEL	3.5E-3	Groundwater Ingestion	4.7E-3	Groundwater Ingestion
LANL	8.9E-5	Inhalation	2.4E-7	Inhalation
LLNL	6.5 E-6	Inhalation	5.0E-6	Groundwater Ingestion
ORNL	7.5E-7	Groundwater Ingestion	5.9E-7	Groundwater Ingestion
RFETS	7.2 E-3	Inhalation	2.1E-7	Groundwater Ingestion
SRS	2.7 E-3	Inhalation	3.1E-4	Groundwater Ingestion
Population Impacts				
Hanford	0.01	Inhalation	7.5E-9	Inhalation
INEL	0.2	Inhalation	5.8E-6	Inhalation
LANL	0.2	Inhalation	4.7E-4	Inhalation
LLNL	0.01	Inhalation	2.5E-7	Inhalation
ORNL	3.2E-4	Inhalation	4.9E-7	Surface Water Ingestion
RFETS	20.9	Inhalation	7.4E-4	Inhalation
SRS	0.65	Surface Water Inhalation	1.1E-7	Surface Water Ingestion

[a] Probability of an LCF for the MEIs; number of LCFs for the populations.

range from 8 x 10^{-5} (at ORNL) to 0.7 (at RFETS) percent chance of an LCF. Carcinogenic hazardous chemical impacts would range from a 2 x 10^{-5} (at LANL) to 0.05 (at INEL) percent chance of a cancer incidence. The predominant impacts at nearly all sites, except for LANL, would result from ingestion of groundwater containing 1,1,2,2-tetrachloroethane. Noncarcinogenic hazardous chemical impacts were estimated using HIs, shown in Table 5-92, and would range from about 4 x 10^{-9} (at RFETS) to 3.2 (at SRS). No noncarcinogenic health effects would occur for an HI less than 1. Noncarcinogenic impacts at all sites would result from ingestion of groundwater containing mercury or carbon tetrachloride.

The estimated lifetime population impacts were estimated from the air and surface water pathway exposures. The groundwater pathway was not considered to be a substantial source of off-site drinking water so it was not considered in the estimation of off-site population impact. As for the MEIs, impacts to populations were estimated for 70-year lifetimes over the 10,000 years of environmental release of contaminants from buried and surface-stored waste at the seven major

Table 5-92
Noncarcinogenic HIs for an MEI for Seven Major Generator-Storage Sites

Major Generator/ Storage Sites	HI[a]	Key Chemical	Dominant Pathway
Hanford	0.2	Mercury	Groundwater Ingestion
INEL	0.5	Carbon Tetrachloride	Groundwater Ingestion
LANL	1.9E-3	Mercury	Resuspended Soil Ingestion
LLNL	0.3	Carbon Tetrachloride	Groundwater Ingestion
ORNL	1.3E-4	Mercury	Groundwater Ingestion
RFETS	3.5E-9	Carbon Tetrachloride	Groundwater Ingestion
SRS	3.2	Mercury	Groundwater Ingestion

[a] No noncarcinogenic impacts would occur for an HI less than 1.

generator-storage sites. The maximum lifetime population impacts over this period are also presented in Table 5-91. Depending upon the site, the pathway, and the impact measure, the time of maximum impact could begin from 35 to 9,900 years after the loss of institutional control. Radiological impacts to populations would range from 3×10^{-4} (at ORNL) to 21 (at RFETS) LCFs over the 70-year period. Carcinogenic hazardous chemical impacts would range from 8×10^{-9} (at Hanford) to 7×10^{-4} (at RFETS) cancers over the 70 year period. The aggregate radiological impact from the seven sites over 10,000 years was estimated to be about 2,325 LCFs with about 99 percent of these LCFs in the population around RFETS. The aggregate hazardous chemical impact from the seven sites over 10,00 years was estimated to be about 0.25 cancers.

The radiological and hazardous chemical impacts estimated for this alternative are based on current storage site population distributions. At present, most sites are remote from large population centers. While it is unknown how populations will change at the sites in the future, over 10,000 years, populations may increase substantially over present day levels and encroach onto the site and near storage facilities. Thus, the potential for additional impacts may increase and potential long-term radiological and hazardous chemical impacts could be considerably higher (i.e., an order of magnitude or more) than impacts estimated in this analysis.

5.7 RETRIEVAL AND RECOVERY

Waste "retrieval," as defined by the WIPP LWA, is "the removal of TRU waste and the container in which it has been retained, and any material contaminated by such waste from the underground repository at WIPP." For the purposes of analyses, SEIS-II distinguishes between waste "retrieval" and waste "recovery." Retrieval is the removal of intact (unbreached) waste containers. Retrieval is presumed to occur prior to the closure of WIPP before salt reconsolidation (rock creep) begins to crush CH-TRU waste drums and standard waste boxes or RH-TRU waste canisters. Waste "recovery" assumes that the waste containers would be breached through the process of salt reconsolidation and would include the removal of waste, waste containers, and any material contaminated by such waste. The analysis of waste removal at some future time is based on the following general assumptions: (1) the reason for removing the waste would be known; (2) the transportation mode, destination, and end use would be known; (3) waste removal would be based on future available technologies and future regulations.

The consequence analysis presented in the following subsections is intended to bound the impacts that could occur in the unlikely event that waste would need to be removed from the WIPP repository. If one or more panels of waste were removed after the panels had been closed but prior to repository closure, the impacts of waste removal would be proportional to the number of panel equivalents removed. In general, worker impacts would increase in proportion to the number of waste containers that have been breached.

5.7.1 Waste Retrieval

The retrieval of waste from WIPP prior to closure would conceptually be the reverse of the initial disposal. Because the facility would not have been closed, it was assumed that (1) the surface facilities, equipment, and shafts would be intact and operational, (2) access to the waste would be available via the access tunnels, (3) panel rooms would not have collapsed, and (4) the waste containers would be unbreached and intact. For this analysis, it was assumed that one panel of waste (17,560 cubic meters [620,000 cubic feet]) would be removed. This is equal to 10 percent of the Basic Inventory, the total of which is proposed for disposal in ten panel equivalents. If more than one panel were retrieved, the impacts would be proportional to the number of panel equivalents retrieved.

5.7.1.1 Operational Impacts of Waste Retrieval

Operational impacts of retrieving CH-TRU and RH-TRU waste from one panel-equivalent would be essentially the same as the impacts of emplacing that waste. Approximately 40 workers would be involved with removing the waste from the panel on a daily basis for a period of 2 years. The worker-population dose for this operation would not exceed 80 person-rem, based on WIPP administrative limits of 1 rem TEDE per year, and would probably be much smaller. The number of LCFs in the worker population from this exposure would be about 0.03. The potential of cancer incidence from exposure to hazardous chemicals would be smaller, on the order of 5×10^{-6}. No noncarcinogenic effects from exposure to hazardous chemicals would be expected.

Impacts to the public and to noninvolved workers would be expected to be smaller, by at least an order of magnitude, than the values for WIPP operations under the Proposed Action (Tables 5-11 and 5-12). The estimated number of LCFs in the general population from radiation exposure was 3×10^{-5}, while cancer incidence from hazardous chemical exposure was about 2×10^{-6}. The MEI would have a 3×10^{-6} percent chance of an LCF from radiation exposure and about a 3×10^{-7} percent chance of a cancer incidence. The noninvolved worker population would have an estimated 1×10^{-3} LCF from radiation exposure and cancer incidence from hazardous chemical exposure would be about 1×10^{-5}. The maximally exposed noninvolved worker would have a 1×10^{-5} percent chance of an LCF from radiation exposure, and about a 1×10^{-6} percent chance of a cancer incidence. No noncarcinogenic health effects would be expected, with HIs not exceeding those under the Proposed Action and no larger than 6×10^{-5}.

5.7.1.2 Transportation Impacts of Waste Retrieval

Transportation impacts from the retrieval of one panel of waste would be the same for transporting the waste to WIPP for disposal. The impact of transporting waste is primarily based on the number of shipments required and the shipping destination distances. Because the amount of waste would be the same as originally disposed of, and the waste would be shipped back to the origination site, the number of shipments and shipping destinations would be the same, making the transportation impact the same. The estimated impacts of transporting one panel of TRU waste removed from WIPP to the waste origination site would be less than one vehicle-related fatality and less than one nonoccupational LCF (see Appendix E).

5.7.2 Waste Recovery

Recovery of waste from WIPP would occur during operations or post-closure. Post-closure recovery would include require the sinking of new shafts and excavating new drifts. For this analysis it was assumed that standard mining techniques would be used until excessive contamination or radiation fields are encountered. In contaminated areas, currently available remote-controlled mining equipment or equipment modified with off-the-shelf systems may be used. Where practical, removal operations would be performed remotely. All support, radiation and air quality monitoring, and geotechnical surveying would be performed remotely in the contaminated areas. Unpolluted and contaminated materials would be segregated and maintained using separate air intake paths and ventilation control structures.

Excavated waste materials would be placed in appropriately designed waste containers. The surfaces of the containers would be decontaminated, if necessary, prior to being transported aboveground. Aboveground facilities would include a control center where all remote operations would be coordinated and a decontamination area where waste containers would undergo additional decontamination if necessary. The waste containers would be staged aboveground for

transportation to a pre-determined location or end use. A control center in the underground would provide the interface between the aboveground control center and underground operational activities.

The mining and waste removal operations would be designed to reduce the amount of contamination and exposure, and to allow limited human access for assessments, equipment retrieval, and equipment repairs. All operations would be designed to reduce or eliminate human involvement. Any radiological work would be performed using standard industry practices and approved procedures.

The mining operations would use standard equipment to sink the shafts and to excavate the drifts and support rooms. After the underground support areas have been completed, the waste would be removed. Reduced scale mining equipment would be used to perform the removal. A reduction in scale would enable the vehicles and supporting equipment to be remotely controlled and to handle waste materials not usually associated with mining activities. The CH-TRU and RH-TRU waste would be retrieved in separate operations. The RH-TRU waste would be removed as intact as possible. Because the RH-TRU waste poses a greater external radiation hazard, RH-TRU waste removal activities would require more rigorous measures to limit personnel exposure.

It is anticipated that a long time period would be needed to complete the removal of waste, but no time limit would be specified. The removal approach would minimize the overall hazards.

After the waste has been removed from the repository, the facility would be decommissioned in accordance with the regulatory requirements applicable at that time. Closure may include partial backfilling of the repository and support areas. The entire repository would not be backfilled; however. The intent would be to dispose of uncontaminated excavated salt and other materials removed from the underground during the initial mining operations. The shafts may be sealed; surface facilities would be decontaminated and decommissioned. All decontamination waste could be packaged and shipped in the same fashion as the waste removed.

The analysis for the recovery of waste after closure is based on the assumptions that (1) the repository has been closed for a period of time sufficient for total encapsulation of the waste and reconsolidation of the salt, (2) waste containers have been breached, and (3) waste characterization requirements and the process/equipment that meet these requirements are known and are based on regulations current at the time of removal.

A volume of 400,000 cubic meters (14 million cubic feet) of CH-TRU and RH-TRU waste is assumed to have been disposed of. This volume, which is equal to the volume of waste disposed of under Action Alternative 3, is equivalent to 71 full panels. To recover the disposed of waste, the materials that would be removed from the repository would include 3,370,000 cubic meters (119 million cubic feet) of contaminated material and 570,000 cubic meters (20 million cubic feet) of uncontaminated material. These volumes include uncontaminated materials from newly excavated repository shafts and access drifts and contaminated materials from the waste panel rooms and drifts, plus an additional 10 percent to include contaminated materials that may have penetrated into the disposal panel or drift floors or walls.

5.7.2.1 Operational Impacts of Waste Recovery

Operational impacts of recovering emplaced CH-TRU and RH-TRU waste from the entire repository 100 years after closure would be substantially greater than the impacts of emplacing the waste. In addition to excavation of waste, containers, and surrounding contaminated salt, there would be substantial effort involved in packaging the material for safe shipment. The number of

workers required for excavation and packaging activities was estimated to be about 100. The time period needed to remove the waste was estimated to be about the same as that required for emplacement, about 200 years, based on 5 years to excavate and package each panel containing CH-TRU and RH-TRU waste, and 2 years to excavate and package each panel containing only RH-TRU waste.

Involved workers were assumed to be administratively limited to 1 rem TEDE per year. Based on 100 workers and a 35-year work period per worker, the accumulated worker-population dose over the entire 200-year recovery period would be 20,000 person-rem. The maximum accumulated LCFs in the involved worker population would be about 8. The accumulated potential of cancer incidence from exposure to hazardous chemicals would be smaller, on the order of 1×10^{-3}. No noncarcinogenic effects from exposure to hazardous chemicals would be expected.

Impacts to the public and noninvolved workers would be expected to be about three orders of magnitude (1,000 times) larger than the values for WIPP operations under Action Alternative 3 (Tables 5-64 and 5-65). The estimated number of LCF in the general population from radiation exposure would be 0.2, while cancer incidence from hazardous chemical exposure would be 0.01. The MEI would have a 3×10^{-2} percent chance of an LCF from radiation exposure, and about a 1×10^{-3} percent chance of a cancer incidence. The noninvolved worker population would have an estimated 0.3 LCF from radiation exposure, and cancer incidence from hazardous chemical exposure would be about 0.05. The maximally exposed noninvolved worker would have a 3×10^{-2} percent chance of an LCF from radiation exposure, and about a 5×10^{-3} percent chance of a cancer incidence. No noncarcinogenic health effects would be expected, with the HIs not exceeding those under Action Alternative 3 and no larger than 1×10^{-3}.

5.7.2.2 Transportation Impacts of Waste Recovery

The transportation impacts of recovering the waste would be substantially greater than for its disposal because there would be a much greater volume of recovered waste (3.4 million cubic meters [20 million cubic feet]). It is assumed that the recovered waste would be transported to the treatment sites using the transportation consolidation described for Action Alternative 3. Because contaminated salt would be treated as waste, each generator site would receive more waste than it originally shipped for disposal.

The large volume of contaminated salt would increase the number of shipments by a factor of 8.5, increasing the transportation impact by approximately the same factor. This impact estimate is conservative because, in the time between disposal and recovery, the radionuclides with short half-lives would have decayed sufficiently to reduce accident-free radiological impacts to a large extent. Also, because much of the recovered waste would have a large salt component, the salt would provide shielding for the radioactive component. This self-shielding effect would further reduce accident-free impacts. The bounding accident impacts, however, would be about the same as that calculated for Action Alternative 3 (3 LCFs for CH-TRU waste average radionuclide concentration scenario) because the half-life of the alpha emitting radionuclides, which contribute most to internal dose, have relatively long half-lives. After 100 years, these radionuclides would not have decayed sufficiently enough to substantially reduce impacts. The maximum radiological populations impacts calculated to occur from nonoccupational exposures is estimated to be the same as Action Alternative 3 (14 LCFs). Vehicle-related traffic fatalities would increase to 213 due to a proportional increase in waste and transportation miles (see the related discussion in Appendix E for complete estimated transportation impacts).

5.8 ENVIRONMENTAL JUSTICE

DOE is in the process of developing environmental justice guidance, pursuant to Executive Order 12898. This guidance will be finalized after stakeholder comments, concerns, and opinions are received, reviewed, and incorporated, as appropriate.[1] The approach taken in this SEIS-II analysis may depart somewhat from the guidance that is eventually issued or from the approach taken in other documents.

For purposes of this analysis, a high and adverse human health or environmental impact is a deleterious human health or environmental impact. A disproportionately high and adverse impact to a minority or low-income population is one that substantially exceeds the same type of impact in the larger community. A disproportionately high and adverse human health or environmental effect would occur when the human health risks are significant or the risk or rate to a minority or low-income population from exposure to an environmental or health hazard substantially exceeds the risk or rate to the general population.

The SEIS-II environmental justice analysis addresses the potential for disproportionately high and adverse human health or environmental effects on minority and low-income populations within an 80-kilometer (50-mile) area of the WIPP site. The shaded areas in Figures 4-7 and 4-8 show the percentage of minority populations and low income populations, respectively, in census blocks around the WIPP site. Minorities comprise about 36.8 percent of the population in the 80-kilometer (50-mile) area around WIPP, and low-income individuals about 21.5 percent of this population.

The populations within an 80-kilometer (50-mile) area of the other treatment sites are described in Chapter 4 of SEIS-II. SEIS-II also incorporates by reference the maps of the census tracts containing greater than 50 percent minority and low-income populations within the 80-kilometer (50-mile) area of treatment sites that are included in Appendix I of the Draft WM PEIS (DOE 1995f). Of note for environmental justice assessments are LANL and SRS, where minorities constitute greater than 55 percent and 35 percent, respectively, of the total populations within the 80-kilometer (50-mile) area (DOE 1996e and 1996d).

For treatment, potentially high and adverse human health effects could occur during normal, accident-free treatment operations at some treatment sites as a result of TRU waste management activities under the three Action Alternative 2 subalternatives. Several segments of the population in the vicinity of WIPP contain a greater percentage of minorities than some areas within the 80-kilometer (50-mile) area of WIPP and the population of the United States as a whole. It is possible, therefore, that adverse health impacts (estimate of 1 fatality) from routine or accident-free thermal treatment of waste at WIPP under Action Alternative 2C would disproportionately affect the minority populations in the vicinity of WIPP. The prevailing winds at both SRS and LANL would direct treatment releases away from the concentrations of minority and low-income populations that exist around those sites. At all treatment sites, treatment accidents would be unlikely so that accidents would not be expected to impact off-site populations; also the impacts from treatment accidents would depend on meteorological conditions at the time of the accident. For these reasons, it is not likely that adverse environmental or human health impacts would disproportionately affect the minority or low-income populations at any of the treatment sites.

Potentially high and adverse impacts as defined above may occur as a result of waste transportation activities. Routine transportation could cause up to 15 public fatalities over the life of the project from radiation exposure primarily to the population near locations where trucks routinely stop. Up

[1] The Council on Environmental Quality has also developed draft "Guidance for Addressing Environmental Justice Under the National Environmental Policy Act."

to 303 fatalities could occur from traumatic injuries sustained in accidents involving transportation vehicles. Severe transportation accidents that breach the transport package could result in 16 LCFs under any alternative. However, accidents would be random events that could occur on any segment of the transportation route and thus would not be likely to disproportionately affect minority or low-income populations.

For disposal at WIPP, normal accident-free operations would not cause significant adverse human health or environmental impacts, and thus there would be no such impacts that could disproportionately affect minority or low-income populations. For disposal accidents, the most severe accident (the waste hoist failure) could cause up to 4 public fatalities for the Proposed Action and up to 24 fatalities for Action Alternative 3. However, the annual probability of this accident is 4.5×10^{-7}. Therefore, although possible, disproportionately high and adverse effects on minority or low-income populations would not be expected.

5.9 CUMULATIVE IMPACTS

This discussion focuses on cumulative impacts that could result from incremental impacts of the Proposed Action and the alternatives analyzed in SEIS-II, when added to other past, present, and reasonably foreseeable future actions. The discussion of cumulative impacts from transportation and at sites other than WIPP is based primarily on the cumulative impacts discussion from the Draft WM PEIS. The assessment, though, has been updated to reflect the SEIS-II analyses and encompasses impacts from other ongoing NEPA documents, including the following programmatic environmental impact statements:

- *Storage and Disposition of Weapons-Usable Fissile Materials Draft Programmatic Environmental Impact Statement* (DOE 1996d)
- *Draft Programmatic Environmental Impact Statement for Stockpile Stewardship and Management* (DOE 1996c)
- *Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling* (DOE 1995i)
- Other, site-specific NEPA documents were also considered, including: the *Savannah River Site Waste Management Final Environmental Impact Statement* (DOE 1995e) and draft of *The Environmental Impact Statement for the Nevada Test Site and Offsite Locations in the State of Nevada* (DOE 1996a).

5.9.1 Cumulative Impacts in the Vicinity of WIPP

The WIPP site has been withdrawn for the purpose of TRU waste disposal and related activities and DOE has no plans to conduct any other type of activity on the site. It is possible that waste or materials not currently defined as TRU waste could become TRU waste that could be disposed of at WIPP. Currently, DOE is planning or discussing plans that could create two additional sources of TRU waste. These additional sources are, therefore, considered reasonably foreseeable.

DOE is planning to treat low-level alpha mixed waste at INEL with a thermal process that would reduce the waste volume and concentrate TRU radionuclides. If INEL decides to use such a treatment process, all or a portion of the resulting waste form could become CH-TRU waste after treatment. The thermally treated low-level alpha mixed waste would have characteristics similar to the other CH-TRU waste examined in this analysis, and disposal of this waste at WIPP would have impacts similar to the disposal of any other equivalent volume of CH-TRU waste. The volume of

this waste is estimated to be about 27,000 cubic meters (930,000 cubic feet), which after treatment would occupy most of the projected unused CH-TRU waste disposal capacity of WIPP. While the CH-TRU waste capacity was adjusted up for the purpose of bounding the analysis in the Proposed Action, the results of the analysis would have been essentially the same had the treated low-level mixed waste been assumed to take up the additional volume. Likewise, addition of this relatively small volume of treated TRU waste to the waste volumes examined under any of the SEIS-II alternatives would not substantially affect the environmental impacts of disposal.

DOE is also considering managing some plutonium residues as TRU waste. These residues are stored primarily at Hanford, INEL, LANL, LLNL, RFETS, and SRS. Residues at RFETS were reported as TRU waste volumes in BIR-2 and the impacts of disposal of the RFETS residues were examined as part of the Proposed Action and the alternatives in SEIS-II. The Department would prepare additional NEPA analyses as appropriate concerning residue for WIPP disposal.

Future mining and drilling to extract mineral resources known to exist in the vicinity of WIPP would be prohibited by the LWA in the foreseeable future. Activity on two existing leases would be allowed only if EPA found that such activity would not affect WIPP performance; otherwise, DOE would acquire those leases. The SEIS-II long-term performance assessment elsewhere in Chapter 5 and Appendix H takes into account the potential impacts of mining and drilling activities that might be expected to occur after WIPP closure and the period of active institutional control.

5.9.2 Cumulative Transportation Impacts

The cumulative effects of transporting low-level mixed, low-level, TRU, high-level, and hazardous waste are presented in the Draft WM PEIS. Because SEIS-II has used updated TRU waste volume information; projected waste generation over a longer period of time; and has assumed, for the purposes of analyzing some of the alternatives, that all currently disposed of and buried TRU waste would be retrieved for storage or disposal at WIPP, the number of waste shipments and transportation impacts for TRU waste are generally greater than those reported in the Draft WM PEIS. The following cumulative impact figures were derived by substituting the SEIS-II transportation impacts for the Draft WM PEIS TRU waste transportation impacts in the Draft WM PEIS cumulative impacts analysis.

The revised totals show that transporting waste between generator, treatment, storage, and disposal sites by truck would result in an aggregate total of between 16 and 103 fatalities. Of these fatalities, approximately 6 to 34 would result from radiation exposure of transport crew members and the population along the transport routes to the radioactive components in the waste. Transport by rail would result in a combined total of from 6 to 21 fatalities. Of these fatalities, approximately 1 to 5 would result from exposure of transport crew members and the population along the transport routes to the radioactive components of the waste. Other transportation activities being considered by the Department include transportation of fissile materials for storage and disposition (DOE 1996d). This could result in an additional 1 to 6 traffic fatalities to the totals.

DOE has estimated that approximately 160 radiation-related LCFs may occur in the general population from DOE past, present, and reasonably foreseeable transportation activities (including transportation to WIPP) in the time period of 1943 to 2035, including an estimate of 25 LCFs from reasonably foreseeable actions. DOE has also estimated approximately 130 occupational LCFs, with about 4 LCFs from reasonably foreseeable future actions (DOE 1995b).

5.9.3 Cumulative Impacts at Treatment Sites

The Draft WM PEIS examined the impacts of storage and treatment of TRU waste at major sites. No cumulative impact from TRU waste storage was found at any of the sites examined. In addition, the Draft WM PEIS found little potential for TRU waste treatment to impact water resources, ecological resources, the economy, population, cultural resources, infrastructure, or land use at any individual site, or cumulatively. While SEIS-II waste volumes considered for some alternatives would be approximately twice those considered in the Draft WM PEIS, the cumulative impacts of storing and treating this volume of waste would not be substantially greater than those already considered in the Draft WM PEIS. Draft WM PEIS did find some potential for cumulative health impacts or air quality impacts at some sites. Of the 10 major treatment sites proposed in Draft WM PEIS and included in SEIS-II, the cumulative health impacts at ANL-E and LLNL from waste treatment activities were low, and those sites showed no air quality impacts. Mound Plant was not considered a major waste-management site in Draft WM PEIS, and the cumulative impacts for that site were not addressed. However, based on the SEIS-II analysis, impacts at Mound Plant would be similar to those at ANL-E and LLNL. The following discussions focus on the cumulative impacts of TRU waste treatment on human health and air quality at the seven remaining treatment sites analyzed in SEIS-II.

Hanford Site

The incremental contribution of TRU waste treatment activities to cumulative impacts at Hanford would be expected to increase off-site radiation cancer fatalities by 1×10^{-4} to 0.2, noninvolved worker fatalities by 6×10^{-6} to 0.01, and involved worker fatalities by about 0.2 to 2 (primarily from physical hazards) depending on TRU waste treatment option chosen. Treatment to planning-basis WAC would cause the lowest health impacts, treatment to meet the LDRs would cause the highest impacts. Cumulatively, no additional radiation deaths would be expected from these activities, although two additional worker death from physical hazards might be anticipated. Emissions from TRU waste treatment activities would be 2 percent or less of the applicable prevention of significant deterioration standards for all pollutants; cumulative air quality impacts of waste treatment at Hanford could lead to NO_2 and PM_{10} standards being exceeded.

Idaho National Engineering Laboratory

The incremental contribution of TRU waste treatment activities to cumulative impacts at INEL would be expected to increase off-site radiation cancer fatalities by 4×10^{-6} to 0.2, noninvolved worker fatalities by 6×10^{-10} to 2×10^{-5}, and involved worker fatalities by about 0.04 to 3 (primarily from physical hazards) depending on TRU waste treatment option chosen (treatment to planning-basis WAC would cause the lowest health impacts, treatment to meet the LDRs would cause the highest). Cumulatively, no additional radiation deaths would be expected from these activities, although several additional worker death from physical hazards might be anticipated. Emissions from TRU waste treatment activities would be 4 percent or less than applicable prevention of significant deterioration standard for nitrogen dioxide and from 0 to 17 percent for particulates; cumulative air quality impacts of waste treatment at INEL could lead to PM_{10} standards being exceeded.

Los Alamos National Laboratory

The incremental contribution of TRU waste treatment activities to cumulative impacts at LANL would be expected to increase off-site radiation cancer fatalities by 5×10^{-5} to 0.6, noninvolved worker fatalities by 6×10^{-9} to 7×10^{-5}, and involved worker fatalities by about 0.1 to 0.6 (from a combination of radiation exposure and physical hazards) depending on TRU waste treatment option

chosen (treatment to planning-basis WAC would cause the lowest health impacts, treatment to meet the LDRs would cause the highest). Cumulatively, one additional off-site radiation death, but no worker deaths would be expected from these activities. Emissions from TRU waste treatment activities would be less than 5 percent of the applicable standards for all pollutants except radionuclides. Emissions of radionuclides would be 134 percent of the standards for the alternative that would involve treatment to the LDRs at LANL; mitigation would be necessary to prevent radionuclide levels from exceeding standards in the event LDR treatment of TRU waste at LANL were implemented.

Nevada Test Site

The incremental contribution of TRU waste treatment activities to cumulative impacts at NTS would be expected to increase off-site radiation cancer fatalities by 1×10^{-10} to 2×10^{-10}, noninvolved worker fatalities by 3×10^{-14} to 4×10^{-14}, and involved worker fatalities from 0 to 0.1 (primarily from physical hazards). Cumulatively, no additional radiation deaths would be expected at NTS, and no additional worker deaths from physical hazards would be anticipated. Emissions from TRU waste treatment activities would be 5 percent or less applicable air quality standards for all pollutants; cumulative air quality impacts of waste treatment at NTS could lead to CO and PM_{10} standards being exceeded.

Oak Ridge National Laboratory

The incremental contribution of TRU waste treatment activities to cumulative impacts at ORNL would be expected to increase off-site radiation cancer fatalities by 8×10^{-7} to 0.05, noninvolved worker fatalities by 3×10^{-8} to 2×10^{-3}, and involved worker fatalities by about 0.2 to 0.5 (from a combination of radiation exposure and physical hazards) depending on TRU waste treatment option chosen (treatment to planning-basis WAC would cause the lowest health impacts, treatment to meet the LDRs would cause the highest). Cumulatively, no additional radiation deaths or worker deaths from physical hazards would be anticipated from these activities. Emissions from TRU waste treatment activities would constitute 2 percent or less of the applicable prevention of significant deterioration standard for all pollutants; cumulative air quality impacts of waste treatment at ORNL could lead to NO_2, PM_{10}, and vinyl chloride standards being exceeded.

Rocky Flats Environmental Technology Site

The incremental contribution of TRU waste treatment activities to cumulative impacts at RFETS would be expected to increase off-site radiation cancer fatalities by 2×10^{-4} to 2, noninvolved worker fatalities by 2×10^{-9} to 3×10^{-5}, and involved worker fatalities by about 0.3 to 1 (primarily from physical hazards) depending on TRU waste treatment option chosen (treatment to planning-basis WAC would cause the lowest health impacts, treatment to meet the LDRs would cause the highest). Cumulatively, no additional radiation deaths would be expected from these activities, although one additional worker death from physical hazards might be anticipated. Cumulative air quality impacts of waste treatment at RFETS could lead to exceedances of CO and NO_2 standards.

Savannah River Site

The incremental contribution of TRU waste treatment activities to cumulative impacts at the SRS would be expected to increase off-site radiation cancer fatalities by 5×10^{-5} to 3, noninvolved worker fatalities by 5×10^{-10} to 2×10^{-5}, and involved worker fatalities by about 0.4 to 1 (from a combination of radiation and physical hazards) depending on TRU waste treatment option chosen (treatment to planning-basis WAC would cause the lowest health impacts, and treatment to meet the

LDRs the highest impacts). Cumulatively, 2 to 3 additional off-site radiation deaths and one on-site worker death would be expected at SRS. Emissions from TRU waste treatment activities would be 9 percent or less for all pollutants except radionuclides which would be emitted at a concentration of 48 percent of the standards during LDR treatment at SRS. Cumulative air quality impacts of combined activities at SRS could lead to particulate standards being exceeded.

5.10 MITIGATION MEASURES

Analyses of potential environmental impacts in SEIS-II did not identify the need for any additional mitigation measures above those described in the FEIS (DOE 1980) and SEIS-I (DOE 1990). Most of the previously identified mitigation commitments have been fulfilled at WIPP for construction and predisposal phases or were intended to apply to underground tests at WIPP using TRU waste that never took place. DOE will reevaluate ongoing mitigation measures from the FEIS and SEIS-I and mitigation proposals for the disposal phase in light of SEIS-II analyses. Most of the following mitigation measures are included as part of each alternative and would be implemented by DOE to reduce potential impacts. DOE will specify the mitigation measures to be implemented for the action selected in the Record of Decision.

Air quality impacts may be mitigated by activities to reduce generation of criteria pollutants at WIPP, including the use of proper, low-contaminant fuels; paving heavily trafficked areas; and spraying water on dusty roads to minimize fugitive dust emissions. Similar measures may also be taken during decommissioning to minimize air quality impacts. The HEPA filtration systems are already in place and can be used to mitigate any potential releases of radionuclides from the WIPP waste handling facilities. The use of radiation monitors to activate HEPA filtration of underground exhaust air (a mitigation commitment made in SEIS-I) be reevaluated.

Biological resource impacts would be mitigated by avoiding unnecessary damage to vegetation, wildlife, and soil by controlling traffic, minimizing the areas of disturbance, controlling runoff, and cleaning up spills. Any temporary facilities such as haul roads, stockpiles, and work areas may be restored by regrading, reseeding, and fencing as activities requiring these facilities are completed. Environmental monitoring is ongoing and could continue, as necessary, to provide early warning of affects on the biological environment so that specific mitigative measures could be developed and implemented. DOE plans to return decommissioned land used in the operation of WIPP to a stable ecological condition and maintain or enhance the ecological condition of wildlife habitat within the LWA (DOE 1996b). Disturbed areas would be restored as soon as possible after decommissioning, using methods of soil replacement and revegetation conducive to soil stabilization and wildlife needs.

Cultural resource impacts could be mitigated by performing additional surveys of areas that could be disturbed by surface activities, including those during decommissioning. DOE would attempt to avoid potential cultural and historic sites to the extent possible; if avoidance is not possible, specific mitigation measures would likely be developed in consultation with the State Historic Preservation Office, the Advisory Council on Historic Preservation, and the BLM.

Some socioeconomic impact was mitigated when DOE eliminated the former "Control Zone IV" in the 1980's, releasing the area of this zone that was outside the current Land Withdrawal Boundary and making available an estimated 50 million tons of potash for mining. In the event that either of the no action alternatives were selected, DOE may mitigate impacts to the regional economy by staging worker layoffs over the course of the decommissioning period. DOE could also assist laid-off workers by offering such services as worker training and reeducation programs, and providing relocation services for finding jobs elsewhere in the DOE complex.

Transportation impacts would be mitigated in a variety of ways in addition to using approved routes and transportation packages. Transportation routes can be selected to meet federal and state regulations. Trucks (and rail cars) transporting TRU waste would be inspected and maintained on a regular basis. Drivers would be required to meet strict selection and training criteria. The TRANSCOM system would be used to monitor truck movement at all times when transporting waste to WIPP. Extensive emergency response capability exists and would be maintained at DOE, the trucking contractor, and in communities along the transportation routes to respond in the event of an accident.

Human health impacts to the public and noninvolved worker may be mitigated by using HEPA filtration systems to reduce potential releases of radionuclides or hazardous metals from the WIPP waste handling facilities. Worker safety programs are currently in place at WIPP and could continue, with particular emphasis on the physical hazards of underground operations. Mitigation measures for potential radiological impacts to involved workers include adhering to the ALARA philosophy, area and personnel monitoring, and using shielding and remote-handling equipment when handling high dose rate waste containers. Panel seals would be constructed to reduce operational exposures to VOCs emanating from emplaced waste.

The long-term performance of the repository could be enhanced by taking mitigation measures that include emplacing a chemical backfill with waste in the repository and using plugs and seals in the repository panels, access drifts, and shafts. The performance assessment calculations assumed the use of these mitigation measures. To protect the repository from inadvertent intrusion, hydrocarbon drilling and potash mining in the LWA would continue to be limited by the BLM and DOE.

The need for specific mitigation measures at the treatment sites would be determined in NEPA reviews performed for the construction and operation of treatment facilities. For example, mitigation of human health impacts from atmospheric releases of radionuclides during treatment operations would be evaluated where treatment impacts warrant such mitigation.

5.11 SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The LWA prohibits the extraction of mineral and hydrocarbon resources from the 41-square-kilometer (16-square-mile) Land Withdrawal Area during the period of WIPP disposal operations. After decommissioning and permanent marking, the aboveground area of the WIPP site would be restored by contouring, grading, seeding, and other methods to return it to its natural condition.

5.12 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

The irreversible and irretrievable commitments of resources associated with the operation of WIPP have not changed substantially from those presented in Section 9 of the FEIS and Section 11 of SEIS-I. Land use for the salt storage pile is currently planned as 12 hectares (30 acres) rather than 24 hectares (60 acres). Although this area would be remediated when the WIPP site is closed, residual salt would probably make growth of any but salt-tolerant species unlikely. Retrieval or recovery activities, not previously addressed but discussed in Section 5.7 of this supplemental environmental impact statement would probably result in additional use of resources. Retrieval usage would probably equal normal operating uses for the period these activities were under way, while recovery activities would probably be greater than normal operating usage.

Use of diesel fuel for transportation of waste would be more than estimated previously. The FEIS estimate was about 380 cubic meters (100,000 gallons) per year, or about 9,460 cubic meters

(2.5 million gallons) for the original WIPP operating period of 25 years. While annual fuel consumption would not be greatly different from the FEIS estimates, total fuel consumption would be 2 to 5 times higher under the Proposed Action.

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CHAPTER 6

CHAPTER 6
CONSULTATIONS AND PERMITS

This chapter discusses the results of consultations with various agencies during the preparation of the *Waste Isolation Pilot Plant* (WIPP) *Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II). This chapter also lists active, pending and potentially required permits for WIPP.

The National Environmental Policy Act (NEPA) requires that federal, state, and local agencies with jurisdiction or special expertise regarding environmental impacts be consulted and involved in the NEPA process. Agencies involved include those with authority to issue permits, licenses, and other regulatory approvals. Other agencies also include those responsible for protecting significant resources, such as endangered species or wetlands. All such agencies have been sent copies of this Draft SEIS-II document.

The following governmental agencies were consulted:

- New Mexico Forestry Division, New Mexico Energy, Minerals, and Natural Resources Department, 408 Galisteo, Villagra Building, P.O. Box 1948, Santa Fe, NM 87504 (Karen Lightfoot, 505-827-7865)

- U.S. Fish and Wildlife Service, U.S. Department of Interior, New Mexico Ecological Services State Office, 2105 Osuna Road NE, Albuquerque, NM 87113 (Jennifer Fowler-Propst, State Supervisor, 505-761-4525)

- New Mexico Game and Fish Department, P.O. Box 25112, Santa Fe, NM 87504 (Jerry Maracchini, Director, 505-827-9912)

These agencies were contacted in September 1995 in regards to federal- and state-listed endangered, threatened, and candidate plant species. The agencies responded with species lists (Sivinski and Lightfoot 1995, NMDG&F 1995, and USFWS 1995). Table 4-1 lists the species of special concern for the area surrounding the WIPP site.

Also required by NEPA is a list of permits that are active, pending, or potentially required before disposal can begin at WIPP. Table 6-1, which presents this information, begins on the next page.

Table 6-1
Active, Pending, and Potentially Required Permits for the Waste Isolation Pilot Plant Disposal Operations

Granting Agency	Type of Permit	Permit Status
U.S. Department of the Interior, BLM	Right-of-Way for Water Pipeline	Active
U.S. Department of the Interior, BLM	Right-of-Way for the North Access Road	Active
U.S. Department of the Interior, BLM	Right-of-Way for Railroad	Active
U.S. Department of the Interior, BLM	Right-of-Way for Dosimetry and Aerosol Sampling Sites	Active
U.S. Department of the Interior, BLM	Right-of-Way for Seven Subsidence Monuments	Active
U.S. Department of the Interior, BLM	Right-of-Way for Aerosol Sampling Site	Active
U.S. Department of the Interior, BLM	Right-of-Way for Ten Raptor Nesting Platforms	Active
U.S. Department of the Interior, BLM	Right-of-Way for Survey Monument Installation	Active
U.S. Department of the Interior, BLM	Approval to Drill two New Test Walls on Existing Pads at P-1 and P-2	Active
U.S. Department of the Interior, BLM	Free Use Permit for Caliche	Active
N.M. Environment Department	Open Burning Permit to Train Fire Control Crews	Active
N.M. Environment Department	Operating Permit for two Backup Generators	Active
N.M. Environment Department	RCRA Part B Permit Application	Pending
N.M. Environment Department	Acknowledgment of Notification of Hazardous Waste Activity	Active
N.M. Department of Game and Fish	Individual Banding	Active
N.M. Department of Game and Fish	Master Collecting	Active
N.M. Department of Game and Fish	Concurrence that WIPP disposal activities will have no significant impact on State-listed threatened or endangered species	Active
U.S. Department of the Interior, Fish and Wildlife Service	Master Personal Banding	Active
U.S. Department of the Interior, Fish and Wildlife Service	Concurrence that WIPP disposal activities will have no significant impact on Federally listed, threatened, or endangered species	Pending
N.M. Department of Finance and Administrative Planning Division, Historic Preservation Bureau	Concurrence that the DOE Archaeological Resources Protection Plan is adequate to mitigate any adverse impacts upon cultural resources resulting from construction of the WIPP facility	Active
Advisory Council on Historic Preservation	Preservation program under the National Historic Preservation Act	Potential
U.S. Department of Interior	Disposition of Native American Cultural items in accord with the Native American Grave Protection and Repatriation Act	Potential
U.S. Environmental Protection Agency	Notification of the presence of two Underground Storage Tanks	Active
U.S. Environment Protection Agency	N.M. NPDES Storm Water General Permit	Active
U.S. Environmental Protection Agency	No Migration Variance Petition	Pending
U.S. Environmental Protection Agency	Certification of Compliance with 40 CFR 191	Pending

N.M. = New Mexico
BLM = Bureau of Land Management

Table 6-1
Active, Pending, and Potentially Required Permits for the Waste Isolation Pilot Plant Disposal Operations-Continued

Granting Agency	Type of Permit	Permit Status
U.S. Nuclear Regulatory Commission	Certificate of Compliance for the TRUPACT-II	Active
U.S. Nuclear Regulatory Commission	Certificate of Compliance for the RH-72B cask	Pending
N.M. Commissioner of Public Lands	Right-of-Way for High Volume Air Sampler	Active
N.M. State Engineer Office	H-19b1 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b2 well, permit to appropriate the under waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b3 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b4 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b5 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b6 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	H-19b7 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-1 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-2 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-3 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-4 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-5 well, permit to appropriate the underground waters of N.M. for monitoring ad characterization	Active
N.M. State Engineer Office	WQSP-6, well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active
N.M. State Engineer Office	WQSP-7 well, permit to appropriate the underground waters of N.M. for monitoring and characterization	Active

N.M. = New Mexico
BLM = Bureau of Land Management

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APPENDIX A

APPENDIX A
WASTE INVENTORY

This appendix provides information on the characteristics and quantities of transuranic (TRU) waste that may be disposed of at the Waste Isolation Pilot Plant (WIPP). This information is necessary for assessing the potential impacts from the transportation of TRU waste, from WIPP operations, and from the long-term performance of WIPP.

A.1 INTRODUCTION

TRU waste has been generated since the 1940s as part of the nuclear defense research and production activities of the Federal government. Several types of operations generate TRU waste: (1) nuclear weapons development and manufacturing, (2) prior plutonium recovery, (3) research and development, (4) environmental restoration, and decontamination and decommissioning activities, (5) waste management programs, and (6) testing and research at facilities under U.S. Department of Energy (DOE or the Department) contract.

Until about 1970, TRU waste, along with low-level waste, was disposed of in shallow trenches without an intent to retrieve it. In 1970, it was determined that TRU waste should be isolated and disposed of in a different manner than low-level waste. Thus, the Atomic Energy Commission, a DOE predecessor agency, adopted a policy requiring that waste containing TRU elements be placed in containers that could be retrieved from storage within 20 years.

The WIPP Land Withdrawal Act (LWA) (Public Law 102-579) limits (1) the volume of TRU waste that can be disposed of at WIPP to 175,600 cubic meters (6.2 million cubic feet); (2) the total activity of remote-handled (RH) TRU waste to 5.1 million curies (Ci); (3) the activity of RH-TRU waste averaged over the volume of a disposal container to 23 Ci per liter; and (4) the RH-TRU waste volume having a surface dose rate that exceeds 100 rem per hour to 5 percent. DOE and the State of New Mexico agreed to limit the volume of RH-TRU waste to no more than 7,080 cubic meters (250,000 cubic feet) (DOE 1981). This limit results in disposal of RH-TRU waste with total curies below the LWA limit. WIPP capacities for contact-handled (CH) TRU waste and RH-TRU waste are 168,500 cubic meters (5,950,000 cubic feet) and 7,080 cubic meters (250,000 cubic feet), respectively.

As explained in Chapter 2, TRU waste is broadly categorized as (1) those defense wastes that were subject to previous WIPP-related National Environmental Policy Act reviews and (2) other defense and nondefense wastes for which DOE retains management responsibility. TRU wastes analyzed in the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) and the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990) included wastes resulting from defense activities and programs that were placed in retrievable storage pursuant to the 1970 Atomic Energy Commission policy. TRU wastes that were reasonably expected to be generated by ongoing defense activities and programs were also analyzed. For the purpose of this *Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II), this TRU waste inventory is referred to as the "Basic Inventory."

Defense and nondefense TRU wastes that had not previously been analyzed by FEIS and SEIS-I include (1) nondefense and commercial TRU waste, (2) defense TRU waste commingled with

polychlorinated biphenyls (PCB), and (3) defense (and perhaps some nondefense) TRU waste disposed of prior to the Atomic Energy Commission policy of 1970. This TRU waste inventory is referred to as the "Additional Inventory."

A.1.1 Changes and New Information Since SEIS-I

The following major changes in information and assumptions regarding TRU waste differ from those used in SEIS-I (DOE 1990):

- Additional sites that have, or expect to generate, TRU waste have been identified. TRU waste volumes at these sites, however, account for only a small percent of the total TRU waste volume.
- Estimates of the future generation of TRU waste differ for some sites due to changes in those sites' missions.
- More detailed descriptions of the volume and physical characteristics of waste streams have been developed at many sites.
- More detailed descriptions of the radionuclide content of waste streams have been developed at many sites.

In SEIS-I, the volume of TRU waste was estimated at 159,000 cubic meters (5.6 million cubic feet) for CH-TRU waste and 2,690 cubic meters (95,000 cubic feet) for RH-TRU waste. These estimates were based on current volumes of stored waste and waste expected to be generated through the year 2013 (DOE 1990). The volume of TRU waste for the SEIS-II Basic Inventory is estimated at 135,000 cubic meters (4.7 million cubic feet) for CH-TRU waste and 35,000 cubic meters (1.2 million cubic feet) for RH-TRU waste. These estimates are based on current volumes of stored waste and waste expected to be generated through the year 2033.

There is a high level of uncertainty and a current lack of consistent data regarding waste to be produced by decontamination and decommissioning (D&D) and environmental restoration (ER) activities. DOE is developing ER and D&D inventories through the 1995 *Baseline Environmental Management Report* (BEMR) data call (in development). The BEMR data were not available in time to be included in the *WIPP Transuranic Waste Baseline Inventory Report, Revision 2* (BIR-2)[1] or SEIS-II. However, Battelle Columbus Laboratories, Bettis Atomic Power Laboratories (Bettis), and the Hanford Site (Hanford) reported D&D and ER projections that were included in BIR.

Revision 1 of BIR reported Hanford's submittal as approximately 46,000 cubic meters (1.6 million cubic feet) of projected RH-TRU waste, of which 43,000 cubic meters (1.5 million cubic feet) were called "suspect" RH-TRU waste due to insufficient information. Reevaluation of the 46,000 cubic meters (1.6 million cubic feet) of projected RH-TRU waste by Hanford personnel has resulted in a decrease of the reported projected RH-TRU waste to approximately 21,500 cubic meters (760,000 cubic feet) (through the year 2022) for BIR-2. Additional evaluations of the reported Hanford RH-TRU waste volumes are ongoing, and the results will be reported in future revisions

[1] The third revision of the *Baseline Inventory Report* (BIR-3) has been published, but the inventory included in BIR-3 does not include that waste currently not eligible for WIPP. BIR-3 also includes no changes in the volumes reported for that waste currently eligible for WIPP. BIR-2, therefore, is the most appropriate source of data for SEIS-II.

of BIR. Hanford now reports approximately 200 cubic meters (7,000 cubic feet) of stored RH-TRU wastes, with the rest of the waste still to be generated.

A.1.2 Data Sources

Five main data sources were used to develop the TRU waste volume estimates, radionuclide inventories, and hazardous constituent inventories in SEIS-II. These five data sources are the following:

- *WIPP Transuranic Waste Baseline Inventory Report*, Revision 2 (DOE 1995d)
- *Integrated Data Base Report-1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics* (IDB) (DOE 1994a)
- *Waste Isolation Pilot Plant Safety Analysis Report* (SAR) (DOE 1995c)
- *Comment Responses and Revisions to the Resource Conservation and Recovery Act (RCRA) Part B Permit Application* (DOE 1996a)
- *Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (WAC), Revision 5 (DOE 1996b)

The BIR-2 database contains detailed physical descriptions of TRU waste as well as TRU waste volumes and radionuclide inventories associated with individual waste streams at generator-storage sites. The database contains both currently stored waste volumes and waste volumes expected to be generated through the year 2022. BIR-2, WIPP SAR, and the WIPP RCRA Part B Permit Application were used to estimate the inventory of hazardous constituents. Limits for several waste form characteristics, such as thermal power limits, were obtained from the planning-basis WAC.

Not all of the BIR-2 waste streams have associated radionuclide inventories. For example, only about 80 percent of the CH-TRU waste stream volumes and about 15 percent of the RH-TRU waste stream volumes have reported radionuclide inventories. Where possible, BIR-2 radionuclide data were used to analyze the impacts due to TRU waste handling, shipping, and accidents. To supplement missing radionuclide site information, however, an estimate of the total radionuclide inventory for a particular site as reported in the IDB was used. Because data presented in the IDB are site-wide, not waste-stream based, the IDB data were used to estimate the total radionuclide inventory of WIPP in the performance assessment calculations of long-term performance.

A.2 WASTE CHARACTERIZATION

DOE has developed waste matrix codes which organize waste streams by their physical and chemical properties. Over 900 waste streams, listed in BIR-2 have been grouped into the following 11 waste matrix code groups or final TRU waste forms: combustible, filter, graphite, heterogeneous, inorganic nonmetal, lead/cadmium metal, uncategorized metal, salt, soil, solidified inorganic, and solidified organic (DOE 1995d). A brief description of each final TRU waste form is given in Table A-1.

Table A-1
Final TRU Waste Form Definitions

Final TRU Waste Form	Definition
Combustible	Debris that is approximately 95 percent or more, by volume, combustible materials. Examples of combustible debris are materials constructed of plastic, rubber, wood, paper, and cloth.
Filter	Debris that is approximately 50 percent or more, by volume, High Efficiency Particulate Air (HEPA) filters or additional filters constructed of more than one material type (e.g., metal, inorganic nonmetal, and combustibles).
Graphite	Debris that is approximately 95 percent or more, by volume, graphite-based solid materials. Graphite debris includes crucibles, graphite components, and pure graphite.
Heterogeneous	Debris that is at least 50 percent by volume materials that do not meet criteria for assignment into other categories. For example, waste that is a mixture of metal and combustible debris, neither of which comprises 95 percent or more of the waste by volume.
Inorganic nonmetal	Debris that is approximately 95 percent or more, by volume, inorganic nonmetal material. Examples of waste in this group include glass and ceramics.
Lead/cadmium metal	Debris that is approximately 95 percent or more, by volume, metal that contains bulk lead or cadmium as part of the matrix. Examples of this waste include glovebox parts with lead clad in stainless-steel or cadmium sheets.
Uncategorized metal	Debris that is approximately 95 percent or more, by volume, metal but either lacks sufficient information to enable characterization into one of the other categories or contains both lead and cadmium as part of the bulk matrix.
Salt	Debris that is at least 50 percent by volume salts. Stable pyrochemical salt is an example of this group.
Soil	Debris that is approximately 95 percent or more, by volume, soil. This includes sand, silt, and rock/gravel where rock/gravel volumes total less than 50 percent of the matrix.
Solidified inorganic	Debris that is at least 50 percent by volume inorganic process residues. This group includes solidified sludges and small particles.
Solidified organic	Debris that is at least 50 percent by volume organic process residues. These are defined as process residues with a base structure that is primarily organic. The matrix may contain some inorganic solids content such that approximately 20 percent by weight of the waste would remain as residue ash/solids following incineration. Examples include organic resins, organic sludges and solidified organic liquids.

A.2.1 Planning-Basis WAC

TRU waste must be certified to meet planning-basis WAC before it is transported to WIPP (DOE 1989). WAC established conditions that govern the physical, radiological, chemical composition, and packaging requirements of TRU waste. With a broader scope, WAC Revision 4 (DOE 1991) consolidated all of the requirements for TRU waste storage at WIPP into one document. WAC Revision 5 (DOE 1996b) was published in April 1996, providing an update to the requirements.

In developing TRU waste transportation and disposal volumes, the following criteria consistent with planning-basis WAC were incorporated:

- A TRUPACT-II's maximum gross weight must not exceed 8,730 kilograms (19,250 pounds) and the maximum gross weight of the canister of the RH-72B cask is 3,630 kilograms (8,000 pounds).

- The total gross weight for a truck shipment is 36,300 kilograms (80,000 pounds).
- The maximum thermal power (heat-generating capacity) is 40 watts (W) for a TRUPACT-II container and 300 W for an RH-TRU waste canister.
- The maximum plutonium-239 (Pu-239) equivalent activity (PE-Ci) for untreated CH-TRU waste is 80 PE-Ci for a drum, and 130 PE-Ci for a standard waste box. Untreated CH-TRU waste in 55-gallon drums may contain up to 1,800 PE-Ci of activity if overpacked in standard waste boxes or 10-drum overpacks. Drums containing solidified or vitrified CH-TRU waste may contain up to 1,800 PE-Ci of activity per drum. RH-TRU waste canisters may not exceed 1,000 PE-Ci.

Planning-basis WAC for the TRU waste weight, thermal power, and PE-Ci are discussed in the following sections. These factors are used to determine the number of shipments required for waste streams of varying densities and thermal properties.

A.2.1.1 Weight Limits for Packaging TRU Waste

Weight limits apply to the packaging of CH-TRU waste in 55-gallon drums, TRUPACT-IIs, and RH-72B casks. A CH-TRU waste drum shall not exceed 454 kilograms (1,000 pounds). This limit includes the weight of the drum itself, approximately 27 kilograms (60 pounds). Once the CH-TRU waste drum is loaded onto the TRUPACT-II, additional weight limits apply. In addition, the RH-72B cask is limited to a total waste canister payload of 3,630 kilograms (8,000 pounds).

Below are the weight values associated with TRUPACT-IIs and the tractor and trailer, as taken from the *CH-TRU Waste Packaging Optimization Report* (DOE 1995a):

• Maximum gross vehicle weight	36,300 kilograms (80,000 pounds)
• Maximum tractor and trailer weight	12,700 kilograms (28,000 pounds)
• Maximum loaded individual TRUPACT-II weight	8,730 kilograms (19,250 pounds)
• Average empty individual TRUPACT-II weight	5,760 kilograms (12,705 pounds)
• Weight of pallet, slip sheets, and guide tubes	120 kilograms (265 pounds) per TRUPACT-II
• Seven-pack of empty dunnage drums weight	190 kilograms (420 pounds)

Due to the maximum gross vehicle weight restriction, a shipment consisting of three TRUPACT-IIs per trailer, the maximum number of TRUPACT-IIs for a truck shipment, would not exceed the maximum TRUPACT-II weight limit. The average weight of a drum in this case, as indicated in Table A-2, is 142 kilograms (312 pounds).

Table A-2
CH-TRU Waste Shipping Weights [a]

Number of TRUPACT-IIs per Trailer	Number of Drums per Shipment	Payload per Shipment (kilograms)	Average Drum Weight (kilograms)	Dunnage Weight per TRUPACT-II (kilograms)
3	42	5,950	142	0
2	28	5,710	204	0
2	14	5,330	381	190
2	12	5,272	412	218

[a] Adapted from Table A-1 of the *CH-TRU Waste Packaging Optimization Report* (DOE 1995a)

When two TRUPACT-IIs are shipped with no dunnage, the maximum TRUPACT-II payload for the shipment is equal to two fully loaded TRUPACT-IIs, 5,710 kilograms (12,590 pounds). For shipments of higher density waste, it may be necessary to use dunnage to meet the TRUPACT-II maximum weight restriction while allowing the drums to approach their maximum weight. Table A-2 shows two cases that evaluate the average drum weight when using dunnage. The first case involves a seven-pack of empty drums, to demonstrate the average case. The second case involves eight empty drums per TRUPACT-II, which nearly maximizes the allowable weight of the drum.

RH-TRU waste truck shipments are limited to one RH-72B cask by the maximum gross vehicle weight. Assuming the RH-72B cask is loaded with three drums and spacers, the maximum payload in an RH-72B cask is 3,629 kilograms (8,000 pounds). Because only one cask can be shipped by truck per shipment, the cask can always be maximally loaded. Below is a listing of other weights associated with the RH-72B cask, as taken from SAR (DOE 1994c):

- Gross RH-72B cask weight — 20,412 kilograms (45,000 pounds)
- RH-72B outer cask weight — 12,647 kilograms (27,883 pounds)
- Inner vessel weight — 1,825 kilograms (4,023 pounds)
- Weight of impact limiters — 2,311 kilograms (5,094 pounds)
- Loaded canister weight — 3,629 kilograms (8,000 pounds)

Both the TRUPACT-II and the RH-72B cask can be maximally loaded when shipped by rail. Three TRUPACT-IIs or two RH-72B casks can be loaded onto a single, standard railcar.

A.2.1.2 Planning-Basis WAC Thermal Power Limits

Some heat is generated by TRU waste due to the interaction of alpha radiation, emitted in the radioactive decay of plutonium isotopes, with the walls of the waste container. The amount of heat generated over a given volume depends on the radionuclide activity and the average energy of the alpha particles as they are released during decay.

In addition to heat, hydrogen gas is generated when high-energy alpha particles strike polymers such as plastic. The amount of gas generated is a function of the amount of heat produced from radioactive decay and the amount of plastic material present in the TRU waste. Thermal power limits have been established by the *TRUPACT Content Codes* (TRUCON) to ensure that the concentration of flammable gas within the innermost plastic bag of the waste configuration is less than 5 percent after a 60-day period (DOE 1994b). The 60-day period is assumed to be the maximum time a container would remain in an unvented, loaded TRUPACT-II. As might be expected, the more layers of plastic used in packaging materials, the more restrictive the thermal power limit. Thermal power limits were obtained from Table 6-1 of TRUCON and are included in Tables A-16 through A-22 in Section A.3.10.

A.2.1.3 PE-Ci

The PE-Ci concept was developed to eliminate the dependency of radiological analyses on the specific radionuclide composition of TRU waste streams. The inhalation hazard of radionuclides was normalized to the hazard associated with Pu-239. Because SEIS-II evaluates the radiation hazard associated with individual radionuclides, PE-Ci values were used to evaluated whether the radionuclide inventory of specific waste matrix code groups meet the PE-Ci limits specified in planning-basis WAC (DOE 1996b). Additional detail on the PE-Ci concept can be obtained from Appendix B of the WIPP SAR (DOE 1995c). Specific calculations for an isotopic mix are provided in Table A-2 of the WIPP SAR.

PE-Ci values were calculated for all final TRU waste forms. Radionuclide weighting factors, derived from the normalized inhalation hazards, were taken from the planning-basis WAC (DOE 1996b). One final waste form, CH-TRU salt waste at Idaho National Engineering Laboratory (INEL), slightly exceeds the PE-Ci limits under Action Alternative 2. A value of 142.6 PE-Ci per cubic meter for 8.85 cubic meters (313 cubic feet) of stored waste was calculated. Under the volume reduction assumptions for thermal processing, this yields an equivalent value of 407.5 PE-Ci per cubic meter for 3.1 cubic meters (109 cubic feet) of processed waste. This waste stream would require a volume dilution to 3.3 cubic meters (117 cubic feet) to meet the PE-Ci limit.

All TRU waste volume calculations, including the PE-Ci calculations described above, were performed on integrated data for final TRU waste forms. Each final TRU waste form is comprised of several (8 to 10 on average) individual waste streams. In addition, residue data from Rocky Flats Environmental Technology Site (RFETS) included TRU waste volumes for nine final TRU waste forms. The radionuclide inventory, however, was only given as the radionuclide activity for the total volume. The treatment of the waste streams into final TRU waste forms provides the integrated values for the PE-Ci calculations. Because the radionuclide activity of the waste streams is averaged, however, situations may exist where the activity of a single waste stream, or the combination of particular waste streams, would be high enough to exceed the PE-Ci limits.

A.3 WASTE VOLUMES

BIR-2 contains detailed information on waste streams and volumes according to generator-storage site for the following: (1) TRU waste currently in retrievable storage (the stored volume) and (2) TRU waste expected to be generated in 28 years (the projected volume). In the context of SEIS-II, "TRU waste volumes" refers to the total TRU waste volume disposed of over the lifetime

of WIPP. To be conservative, SEIS-II analyses were based upon an upper TRU waste generation limit taken from BIR-2.

A.3.1 Basic Inventory Volumes

Under the Proposed Action, it is assumed that WIPP operations would begin in 1998 and continue for 35 years, ending TRU waste receipt operations in 2033. Projected TRU waste volumes ($V_{projected}$) are given in BIR-2; however, these values reflect volumes estimated in the year 2022. To estimate the total TRU waste inventory volume at a generator-storage site in 2033, the following calculation was used:

$$V_{site} = V_{stored} + [38\ (R_{generate})] \qquad \text{(Equation A-1)}$$

where

V_{site} = estimated TRU waste volume through the year 2033

V_{stored} = TRU waste volume stored at the generator-storage site in 1995

38 = the number of years of waste generation (35 plus 3 years until 1998)

$R_{generate}$ = ($V_{projected}$) / 28 years; this is the TRU waste volume generation rate

The Basic Inventory TRU waste volume for each generator-storage site is given in Table 2-2, presented in this appendix as Table A-3. These are the final TRU waste form volumes based on the minimum level of treatment necessary to meet planning-basis WAC. Generator-storage site volumes for the year 2022 are provided solely for comparison with the volumes in BIR-2; they are not used in further calculations.

A.3.2 Additional Inventory Volumes

TRU waste in the Additional Inventory includes the following: (1) TRU waste commingled with PCBs at Hanford, INEL, and Mound Plant (Mound); (2) commercial/nondefense waste at ARCO Medical Products Company (ARCO), West Valley Demonstration Project (WVDP), Oak Ridge National Laboratory (ORNL), Lawrence Berkeley Laboratory (LBL), and Knolls Atomic Power Laboratory (Knolls); and (3) previously disposed of TRU waste at a number of sites. These volumes are shown in Table 2-3, presented here as Table A-4.

BIR-2 contains estimates of the total volume of previously disposed of TRU waste by site; however, it does not divide these wastes into CH-TRU and RH-TRU waste categories. The ratio of CH-TRU to RH-TRU waste volumes from the Basic Inventory, therefore, was used to divide the previously disposed of TRU waste into CH-TRU and RH-TRU waste categories on a site-by-site basis. In addition, some site information exists for TRU waste commingled with PCBs, commercial, and nondefense TRU waste in BIR-2. The volumes of these types of waste, expected to be generated by 2033, are also given in Table A-4.

Table A-3
Basic Inventory TRU Waste Volumes[a]

	Stored (1995) (cubic meters)		Estimated Total through 2022[b] (cubic meters)		Estimated Total through 2033[c] (cubic meters)	
Site[d]	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	12,000	200	46,000	22,000	57,000	29,000
Los Alamos National Laboratory (LANL)	11,000	94	18,000	190	21,000	230
Idaho National Engineering Laboratory (INEL)	28,000	220	28,000	220	28,000	220
Argonne National Laboratory - West (ANL-W)	7	19	750	1,300	1,000	1,700
Argonne National Laboratory - East (ANL-E)	25	---[e]	150	---	200	---
Savannah River Site (SRS)	2,900	---	9,600	---	12,000	---
Rocky Flats Environmental Technology Site (RFETS)	4,900	---	9,300	---	11,000	---
Oak Ridge National Laboratory (ORNL)	1,300	2,500	1,600	2,900	1,700	3,100
Lawrence Livermore National Laboratory (LLNL)	230	---	940	---	1,200	---
Nevada Test Site (NTS)	620	---	630	---	630	---
Mound Plant (Mound)	300	---	300	---	300	---
Bettis Atomic Power Laboratory (Bettis)	---	---	120	7	170	9
Sandia National Laboratories - Albuquerque (SNL)	7	---	14	---	17	---
Paducah Gaseous Diffusion Plant (PGDP)	---	---	6	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	3	---
Energy Technology Engineering Center (ETEC)	2	6	2	7	2	7
University of Missouri Research Reactor (U of Mo)	1	---	1	---	1	---
Pantex Plant (Pantex)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	---	---	1	---	1	---
Teledyne Brown Engineering (TBE)	1	---	1	---	1	---
Battelle Columbus Laboratories (BCL)	---	580	---	580	---	580
Totals	**62,000**	**3,600**	**116,000**	**27,000**	**135,000**	**35,000**

[a] The inventory for SEIS-II is based on BIR-2 (DOE 1995d), which takes into account potential thermal treatment at some sites. The thermal treatment is not necessarily for PCB-commingled waste. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Post-1970 defense TRU waste volumes through 2022 are estimated in BIR-2 (DOE 1995d).
[c] The Proposed Action, described in Chapter 3, is based on operation of WIPP for 35 years through 2033.
[d] Sites in boldface were included in SEIS-I. INEL and ANL-W are located near each other and are counted as a single site in SEIS-II; however, ANL-W is listed separately to indicate its contribution to the inventory.
[e] Dashes indicate no waste.

A.3.3 Waste Volumes for the Proposed Action

Under the Proposed Action, CH-TRU waste would be consolidated at 10 sites and RH-TRU waste consolidated at four sites before shipment to WIPP. Figure 3-1 identifies the treatment sites for the Proposed Action. Table 3-1, presented here as Table A-5, identifies the treatment sites and waste volumes for the Proposed Action. These volumes are projected for the year 2033. Table A-5 differs from Table 3-1 in that an additional column entitled "Disposal Volume" for RH-TRU waste has been added.

The volumes in BIR-2 represent WIPP disposal volumes. They do not, however, account for volume dilution required for some CH-TRU waste streams in order to meet thermal power (hydrogen gas generation) limits for transportation in the TRUPACT-II containers. The CH-TRU waste volumes in the "Post-Treatment Disposal Volumes" column in Table A-5 include volume expansion due to packaging to meet thermal power limits. These are the anticipated TRU waste volumes that would be disposed of at WIPP.

Table A-4
Additional Inventory TRU Waste Volumes[a, b]

Site[c]	PCB (cubic meters)		Commercial/Nondefense (cubic meters)		Previously Disposed of (cubic meters)		Total (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	240	---	---	---	63,000	1,000	63,000	1,000
Los Alamos National Laboratory (LANL)	---	---	---	---	14,000	120	14,000	120
Idaho National Engineering Laboratory (INEL)	460	---	---	---	57,000	440	57,000	440
Savannah River Site (SRS)	---	---	---	---	4,900	---	4,900	---
Oak Ridge National Laboratory (ORNL)	---	---	5	---	61	120	66	120
Mound Plant (Mound)	19	---	---	---	---	---	19	---
Sandia National Laboratories - Albuquerque (SNL)	---	---	---	---	1	---	1	---
ARCO Medical Products Company (ARCO)	---	---	1	---	---	---	1	---
Knolls Atomic Power Laboratory (Knolls)	---	---	---	81	---	---	---	81
Lawrence Berkeley Laboratory (LBL)	---	---	2	---	---	---	2	---
West Valley Demonstration Project (WVDP)	---	---	190	370	---	1,400	190	1,700
Totals	**720**	**---**	**200**	**450**	**138,000**	**3,100**	**139,000**	**3,500**

[a] The volume of TRU waste represents the 1995 existing and projected waste (DOE 1995). The thermal treatment, though, is not necessarily for PCB-commingled waste.
[b] Actual totals may differ due to rounding.
[c] Sites in bold face also store post-1970 defense TRU waste, see Table 2-2. The remaining four sites currently have no post-1970 defense TRU waste.

Table A-5
TRU Waste Volumes (Basic Inventory) for the Proposed Action [a]

Site[d]	Site Volume Through 2033 (cubic meters)		Pretreatment Consolidated Volume[b] (cubic meters)		Post-Treatment Disposal Volume (cubic meters)		Disposal Volume (cubic meters)[c]
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU[e]	RH-TRU[f]	RH-TRU
Hanford Site (Hanford)	57,000	29,000	57,000	29,000	57,000	42,000	2,800
Los Alamos National Laboratory (LANL)	21,000	230	21,000	230	21,000	330	330
Idaho National Engineering Laboratory (INEL)[g]	28,000	220	29,000	2,000	30,000	2,800	2,800
Argonne National Laboratory - West (ANL-W)	1,000	1,700	---[h]	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	200	---	---
Savannah River Site (SRS)	12,000	---	12,000	---	12,000	---	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	17,000	---	---
Oak Ridge National Laboratory (ORNL)	1,700	3,100	1,800	3,700	1,900	5,300	1,100
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	1,200	---	---
Nevada Test Site (NTS)	630	---	630	---	630	---	---
Mound Plant (Mound)	300	---	300	---	340	---	---
Bettis Atomic Power Laboratory (Bettis)	170	9	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	---	---	---	---	---
Energy Technology Engineering Center (ETEC)	2	7	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	---	580	---	---	---	---	---
Total	**135,000**	**35,000**	**135,000**	**35,000**	**143,000[i]**	**50,000**	**7,080[j]**
Disposal Volume Allowed by WIPP LWA and Agreement for Consultation and Cooperation (C & C)	---	---	---	---	**168,500[i]**	**7,080**	---

[a] The inventory for SEIS-II is based on BIR-2, which took into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment does not necessarily include PCB-commingled waste. Volumes have been rounded. Actual totals may differ due to rounding. The site volumes through 2033 match the final columns on Table 2-2.

[b] Volumes include consolidation of waste as indicated on Figure 3-1.

[c] All LANL and INEL RH-TRU waste is assumed to be disposed of; RH-TRU waste disposed of for Hanford would be approximately 2,800 cubic meters; that for ORNL would be 1,100 cubic meters (after consolidation).

[d] Sites in boldface were included in SEIS-I.

[e] Post-treatment volumes have been adjusted to meet packaging and transportation requirements to meet the planning-basis WAC.

[f] Values represent WIPP emplacement volumes, except for Hanford and ORNL.

[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, are counted as one site in SEIS-II.

[h] Dashes indicate no waste.

[i] Though 143,000 cubic meters of CH-TRU waste are part of the Basic Inventory, additional CH-TRU waste may become a part of that inventory should RCRA or CERCLA action lead to retrieval of previously disposed of waste. Therefore, SEIS-II assesses the impact of the entire disposal volume allowed, 168,500 cubic meters.

[j] The LWA limits the total RH-TRU curie content of WIPP to 5.1 million. Under the Proposed Action, the total curie content associated with the 7,080 cubic meters is less than 1 million curies.

The volume expansion for CH-TRU waste is based on the thermal loading (W/cubic meter) of the final waste form and on limits to the thermal loading per container as set by TRUCON. The TRU waste radioisotopic inventory from BIR-2 was used to determine the thermal loading for each site on a final waste form basis. If the calculated thermal power exceeds the thermal power limit, then volume expansion is required. Only a few waste forms need packaging to meet thermal power limits, provided that plastic wrap is not used when the waste drums are filled (bagless posting). If bagless posting is not used, disposal volumes for CH-TRU waste nearly double.

To determine the volume due to expansion ($V_{Expansion}$), the thermal output for the final TRU waste form ($W_{Calculated}$) in watts per cubic meter is divided by the watt limit per cubic meter for the final TRU waste form (W_{Limit}). $W_{Calculated}$ is calculated from the radionuclide inventory waste stream. W_{Limit} values were obtained from Table 6-1 in TRUCON and converted from watts per drum to watts per cubic meter to facilitate calculations and comparisons (DOE 1994b). If the fraction ($W_{Calculated}/W_{limit}$) is greater than 1, it is multiplied by the initial TRU waste volume ($V_{Initial}$) before packaging. Otherwise, the volume due to expansion would remain the same as the volume before packaging. The equation is as follows:

$$\text{For } \left(\frac{W_{Calculated}}{W_{Limit}}\right) > 1;\ V_{Expansion} = \left(\frac{W_{Calculated}}{W_{Limit}}\right) \times V_{Initial} \qquad \text{(Equation A-2a)}$$

$$\text{For } \left(\frac{W_{Calculated}}{W_{Limit}}\right) < 1;\ V_{Expansion} = V_{Initial} \qquad \text{(Equation A-2b)}$$

Thermal processing is assumed to destroy the materials that generate hydrogen gas, so volume expansion due to thermal power is not applied to thermally processed waste. The Savannah River Site (SRS) has indicated that it would package or treat waste as required to meet planning-basis WAC, including gas generation limitations (Williams 1996). The SRS operations are expected to include both thermal processing and transferal of some high-activity waste from the CH-TRU waste to the RH-TRU waste category. It is assumed that there is no net increase or decrease in the volume of CH-TRU waste and RH-TRU waste at the SRS as a result of this processing.

With the RH-TRU waste volume limit at WIPP of 7,080 cubic meters (250,000 cubic feet), the volume disposed of was calculated using the capacity of the waste containers rather than the volume of the waste within the containers. An RH-TRU waste canister has a volume capacity of 0.89 cubic meter (32 cubic feet); therefore, the volume disposed of for one canister is 0.89 cubic meter (32 cubic feet). Three drums would be placed in an RH-TRU waste canister.

It was assumed that all RH-TRU waste would be contained in 55-gallon drums prior to being inserted into RH-TRU waste canisters, and would remain in place by spacers within the canister. The RH-TRU waste canister would, therefore, account for only 0.624 cubic meter (22 cubic feet) of RH-TRU waste at a site. This type of packaging would require approximately 1.43 times as much volume in WIPP as the volumes of waste stored in drums at the sites. This assumption results in an overestimated total volume disposed of relative to current storage practices. Also, for the purpose of the Proposed Action analysis, it was assumed that all sites except Hanford and ORNL are able to send all RH-TRU waste to WIPP. The waste would go to a treatment site and then to WIPP. Hanford and ORNL would only send about 6.7 percent of their RH-TRU waste to WIPP under the Proposed Action. As with CH-TRU waste, the RH-TRU waste disposal volumes are given in the "Post-Treatment Disposal Volumes" column in Table A-5.

A.3.4 Waste Volumes for Action Alternative 1

Under Action Alternative 1, CH-TRU waste would be consolidated at 10 sites and RH-TRU waste consolidated at four sites before shipment to WIPP based on the Draft WM PEIS Decentralized option. The treatment sites under Action Alternative 1 are shown in Figure 3-2. The CH-TRU waste volumes for Action Alternative 1 are given in Table 3-2, presented here as Table A-6. Similarly, the RH-TRU waste volumes under Action Alternative 1 are given in Table 3-3, presented here as Table A-7. The most notable difference under this alternative, as compared to the Proposed Action, is that all of the TRU waste identified in Table A-4 would be sent to WIPP, except for the TRU waste commingled with PCBs.

Under Action Alternative 1, it is assumed that all waste is packaged to meet planning-basis WAC requirements. Table A-6 columns containing CH-TRU waste post-treatment disposal volumes account for the volume expansion that is assumed necessary to meet thermal power limits; therefore, these volumes would be disposed of at WIPP. Tables A-6 and A-7 are divided into columns which identify the amount of waste under the Basic Inventory and Additional Inventory assumed under this alternative.

A.3.5 Waste Volumes for Action Alternative 2

Three important differences impact waste volumes under Action Alternative 2 as compared to the Proposed Action. These differences are: (1) all RH-TRU waste would be disposed of at WIPP rather than being limited to 7,080 cubic meters (250,000 cubic feet), (2) all of the waste identified in Tables A-3 and A-4 would be sent to WIPP, and (3) all waste would be subjected to thermal treatment to meet RCRA Land Disposal Restrictions (LDR) for hazardous constituents. A 65-percent reduction in the TRU waste volume to be disposed of was assumed due to LDR thermal treatment of both CH-TRU and RH-TRU waste. In an operational sense, the volume change for thermal processing would depend heavily on the physical characteristics of the individual waste stream.

Using an aggregate volume reduction factor of 0.35 for all waste treated by thermal processing, the resulting disposal volume for CH-TRU waste was calculated as:

$$V_{Disposal} = (0.35)\ V_{Consolidated} \qquad \text{(Equation A-3)}$$

For RH-TRU waste, the disposal volume resulting from thermal treatment was calculated in a similar manner. A volume expansion factor of 1.43 was applied to account for the placement of three waste drums in an RH-TRU waste canister (Equation A-4).

$$V_{Disposal} = (0.35)\ V_{Consolidated} \times 1.43 \qquad \text{(Equation A-4)}$$

$V_{Consolidated}$ refers to the TRU waste volume prior to thermal treatment. $V_{Disposal}$ refers to the TRU waste volume resulting from thermal treatment that would be disposed of at WIPP.

Thermal processing produces waste in the form of a slag. A density change assumption, therefore, is made such that a 55-gallon drum containing the slag would weigh 454 kilograms (1,000 pounds). Waste density values are used in the determination of the number of shipments (Section A.3.9). See Table A-2 for the CH-TRU average drum weights used to determine the number of shipments.

Table A-6
CH-TRU Waste Volumes for Action Alternative 1[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	57,000	63,000	120,000	57,000	63,000	120,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	21,000	14,000	35,000
Idaho National Engineering Laboratory (INEL)[f]	28,000	57,000	85,000	30,000	57,000	86,000	30,000	57,000	87,000
Argonne National Laboratory - West (ANL-W)	1,000	---[g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	200	---	200	200	---	200
Savannah River Site (SRS)	12,000	4,900	17,000	12,000	4,900	17,000	12,000	4,900	17,000
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	17,000	---	17,000
Oak Ridge National Laboratory (ORNL)	1,700	56	1,700	1,800	260	2,100	1,800	260	2,100
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	1,200	---	1,200	1,200	---	1,200
Nevada Test Site (NTS)	630	---	630	630	---	630	630	---	630
Mound Plant (Mound)	300	---	300	300	---	300	340	---	340
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**136,000**	**273,000**	**135,000**	**138,000**	**273,000**	**143,000**	**138,000**	**281,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-2.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is not included because there would be no thermal treatment under this alternative.
[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste.

Table A-7
RH-TRU Waste Volumes for Action Alternative 1[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	29,000	1,000	30,000	42,000	1,500	43,000
Los Alamos National Laboratory (LANL)	230	120	350	230	120	350	330	170	490
Idaho National Engineering Laboratory (INEL)[f]	220	440	660	2,000	440	2,400	2,800	630	3,400
Argonne National Laboratory - West (ANL-W)	1,700	---[g]	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	2,000	5,600	5,200	2,700	8,000
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	80	80	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**50,000**	**5,000**	**55,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment is not necessarily of PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-2.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] Additional Inventory (no TRU waste commingled with PCBs is included).
[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste.

Three separate waste treatment site options, based on the Draft WM PEIS Regionalized 2, Regionalized 3, and Centralized Alternatives exist under Action Alternative 2. These subalternatives are Action Alternative 2A, 2B, and 2C, respectively. Both the type of waste treatment and the waste volume remain the same for all the Action Alternative 2 subalternatives; only the locations of the waste treatment sites are different. The treatment sites for Action Alternative 2A, 2B, and 2C are indicated in Figures 3-3, 3-4, and 3-5, respectively.

CH-TRU waste volumes for treatment sites under Action Alternative 2A, based on the Draft WM PEIS Regionalized 2 Alternative, are shown in Table 3-4 and presented here as Table A-8. CH-TRU waste volumes for treatment sites under Action Alternative 2B, based on the Draft WM PEIS Regionalized 3 Alternative, are shown in Table 3-6 and presented here as Table A-9. CH-TRU waste volumes for treatment sites under Action Alternative 2C, based on the Draft WM PEIS Centralized Alternative, are shown in Table 3-8 presented here as Table A-10.

RH-TRU waste treatment sites are the same for each of the three Draft WM PEIS waste treatment scenarios. The corresponding RH-TRU waste volumes under Action Alternative 2 are given in Tables 3-5, 3-7, and 3-9. These tables are consolidated here in Table A-11. The total volume of RH-TRU waste to be disposed of at WIPP would be 19,000 cubic meters (670,000 cubic feet). Waste volumes for Action Alternative 2 are all projected to the year 2033.

Table A-8
CH-TRU Waste Volumes for Action Alternative 2A[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	7,400	4,900	12,000
Idaho National Engineering Laboratory (INEL)[f]	28,000	57,000	85,000	30,000	57,000	87,000	10,000	31,000	41,000
Argonne National Laboratory - West (ANL-W)	1,000	---[g]	1,000	---	---	---	---	---	---
Argonne National Laboratory-East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,000	20,000	5,000	1,800	6,800
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	3,800	---	3,800
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	20	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-3.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste.

Table A-9
CH-TRU Waste Volumes for Action Alternative 2B [a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	122,000	21,000	22,000	43,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	28,000	57,000	85,000	62,000	71,000	133,000	22,000	36,000	57,000
Argonne National Laboratory-West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,200	20,000	5,000	1,800	6,900
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-4.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

Table A-10
CH-TRU Waste Volumes for Action Alternative 2C [a]

Site[b]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume (cubic meters)			Post-Treatment Disposal Volume (cubic meters)		
	Basic Inventory	Additional Inventory[c]	Total Inventory	Basic Inventory	Additional Inventory[c]	Total Inventory	Basic Inventory	Additional Inventory[c]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	---[d]	---	---	---	---	---
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	---	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[e]	28,000	57,000	85,000	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,000	---	1,000	---	---	---	---	---	---
Argonne National Laboratory-East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	---	---	---	---	---	---
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	19	320	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
WIPP[f]	---	---	---	135,000	139,000	274,000	47,000	60,000	107,000
Total	**135,000**	**139,000**	**274,000**	**135,000**	**139,000**	**274,000**	**47,000**	**60,000**	**107,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Sites in boldface were included in SEIS-I.
[c] TRU waste commingled with PCBs is included.
[d] Dashes indicate no waste.
[e] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[f] TRU waste is consolidated and treated at WIPP.

Table A-11
RH-TRU Waste Volumes for Action Alternatives 2A, 2B, and 2C [a]

Site [d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	16,000	920	17,000
Los Alamos National Laboratory (LANL)	230	120	350	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory-West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	1,800	960	2,800
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**18,000**	**1,900**	**19,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-5.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is included.
[f] Dashes indicate no waste.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

Accounting both for the large volume reduction factor after waste treatment and for placing three 55-gallon drums into each RH-TRU waste canister, there would be 12,400 cubic meters (438,000 cubic feet) more RH-TRU waste disposed of under Action Alternative 2 than under the Proposed Action.

A.3.6 Waste Volumes for Action Alternative 3

Under Action Alternative 3, CH-TRU waste would be consolidated at five sites and RH-TRU waste would be consolidated at two sites before shipment to WIPP. Figure 3-6 shows the treatment sites under this alternative. CH-TRU waste under Action Alternative 3 are given in Table 3-10 and presented here as Table A-12. The RH-TRU waste volumes under Action Alternative 3 are given in Table 3-11 and presented here as Table A-13. Both the Basic Inventory (Table A-3) and the Additional Inventory, with the exception of TRU waste commingled with PCBs (Table A-4), are sent to WIPP. Shred and grout would be the dominant waste treatment process.

The post-treatment disposal volumes of CH-TRU waste (Table A-12) indicate the volume expansions assumed necessary to meet thermal power limits and due to the shred and grout process. These volumes would be disposed of at WIPP. Post-treatment disposal volumes of RH-TRU waste

Table A-12
CH-TRU Waste Volumes for Action Alternative 3[a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	57,000	63,000	120,000	59,000	63,000	121,000	70,000	75,000	146,000
Los Alamos National Laboratory (LANL)	21,000	14,000	35,000	21,000	14,000	35,000	25,000	17,000	42,000
Idaho National Engineering Laboratory (INEL)[f]	28,000	57,000	85,000	30,000	57,000	86,000	37,000	68,000	105,000
Argonne National Laboratory - West (ANL-W)	1,000	---[g]	1,000	---	---	---	---	---	---
Argonne National Laboratory - East (ANL-E)	200	---	200	---	---	---	---	---	---
Savannah River Site (SRS)	12,000	4,900	17,000	14,000	5,000	20,000	17,000	6,200	23,000
Rocky Flats Environmental Technology Site (RFETS)	11,000	---	11,000	11,000	---	11,000	19,000	---	19,000
Oak Ridge National Laboratory (ORNL)	1,700	66	1,700	---	---	---	---	---	---
Lawrence Livermore National Laboratory (LLNL)	1,200	---	1,200	---	---	---	---	---	---
Nevada Test Site (NTS)	630	---	630	---	---	---	---	---	---
Mound Plant (Mound)	300	---	300	---	---	---	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	---	170	---	---	---	---	---	---
Sandia National Laboratories - Albuquerque (SNL)	17	1	18	---	---	---	---	---	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	8	---	---	---	---	---	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	2	---	2	---	---	---	---	---	---
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---	---	---	---
Pantex Plant (Pantex)	1	---	1	---	---	---	---	---	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---	---	---	---
ARCO Medical Products Company (ARCO)	---	1	1	---	---	---	---	---	---
Lawrence Berkeley Laboratory (LBL)	---	2	2	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	190	190	---	---	---	---	---	---
Total	**135,000**	**138,000**	**273,000**	**135,000**	**138,000**	**273,000**	**168,000**	**166,000**	**334,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-6.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is not included because there would be no thermal treatment under this alternative.
[f] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[g] Dashes indicate no waste.

Table A-13
RH-TRU Waste Volumes for Action Alternative 3 [a]

Site[d]	Site Volume Through 2033 (cubic meters)			Pretreatment Consolidated Volume[b] (cubic meters)			Post-Treatment Disposal Volume[c] (cubic meters)		
	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory	Basic Inventory	Additional Inventory[e]	Total Inventory
Hanford Site (Hanford)	29,000	1,000	30,000	32,000	1,600	33,000	54,000	2,700	57,000
Los Alamos National Laboratory (LANL)	230	120	350	---[f]	---	---	---	---	---
Idaho National Engineering Laboratory (INEL)[g]	220	440	660	---	---	---	---	---	---
Argonne National Laboratory - West (ANL-W)	1,700	---	1,700	---	---	---	---	---	---
Oak Ridge National Laboratory (ORNL)	3,100	120	3,200	3,700	1,900	5,600	6,300	3,300	10,000
Bettis Atomic Power Laboratory (Bettis)	9	---	9	---	---	---	---	---	---
Energy Technical Engineering Center (ETEC)	7	---	7	---	---	---	---	---	---
Battelle Columbus Laboratories (BCL)	580	---	580	---	---	---	---	---	---
Knolls Atomic Power Laboratory (Knolls)	---	81	81	---	---	---	---	---	---
West Valley Demonstration Project (WVDP)	---	1,700	1,700	---	---	---	---	---	---
Total	**35,000**	**3,500**	**39,000**	**35,000**	**3,500**	**39,000**	**60,000**	**6,000**	**66,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Volumes include consolidation of waste as indicated on Figure 3-6.
[c] Post-treatment volumes have been adjusted to meet packaging and transportation criteria.
[d] Sites in boldface were included in SEIS-I.
[e] TRU waste commingled with PCBs is not included because there would be no thermal treatment under this alternative.
[f] Dashes indicate no waste.
[g] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.

(Table A-13) account for volume adjustments pertaining to the placement of three 55-gallon drums into the RH-TRU waste canisters and volume expansion from the shred and grout process.

Using an aggregate volume expansion factor of 1.2 of all waste treated by the shred and grout process, the resulting disposal volume for CH-TRU waste is calculated as:

$$V_{Disposal} = (1.2)\ V_{Consolidated} \qquad \text{(Equation A-5)}$$

As in Equation A-4, an additional volume expansion factor of 1.43 is applied to RH-TRU waste calculations to account for the placement of three waste drums in an RH-TRU waste canister (Equation A-6).

$$V_{Disposal} = (1.2)\ V_{Consolidated} \times 1.43 \qquad \text{(Equation A-6)}$$

The waste density would increase for the shred and grout process because much of the waste drum's void space would be filled. A density increase factor of 1.263 is used for waste streams that are already solidified, and a density increase factor of 2.357 is used for all other waste streams (DOE 1995b).

A.3.7 Waste Volumes for No Action Alternative 1

The TRU waste volumes under No Action Alternative 1A are identical to those under Action Alternative 2A (see Tables A-8 and A-11). Likewise, TRU waste volumes under No Action Alternative 1B are identical to those under Action Alternative 2B (see Tables A-9 and A-11).

Two TRU waste treatment scenarios exist under No Action Alternative 1. No Action Alternative 1A assumes the same waste treatment sites as under the Draft WM PEIS Regionalized 2 Alternative. No Action Alternative 1B assumes the same waste treatment sites as the Draft WM PEIS Regionalized 3 Alternative. Waste treatment would be the same as that in Action Alternative 2; however, TRU waste would be placed in retrievable storage at the treatment sites rather than being sent to WIPP.

A.3.8 Waste Volumes for No Action Alternative 2

TRU waste volumes for No Action Alternative 2, projected to the year 2033, are given in Table 3-16 and presented here as Table A-14. As shown in this table, all RH-TRU waste in the Basic Inventory was included in the analysis. For the purpose of analysis, no consolidation of waste was assumed.

A.3.9 Number of Waste Shipments

The number of shipments required to transport waste from the treatment sites to WIPP primarily depends on the type of waste (CH-TRU or RH-TRU), the waste volume, and the waste density. Some final CH-TRU waste forms are dense enough that TRUPACT-II weight limits impact the number of waste drums that can be carried in one trip (Section A.2.2.1). Material parameter data are found in BIR-2 for most of the 900 waste streams. From the material parameter data, average waste densities were derived for the final waste form at each waste generator-storage site. The average density data were used to estimate the number of truck shipments required to move waste from each site. Table A-15 provides the number of truck shipments from waste treatment sites to WIPP according to waste inventory (Basic or Additional) and alternative, where applicable. It was assumed that thermal processing would result in a dense waste stream such that a standard waste drum would weigh 1,000 pounds (454 kilograms).

The number of RH-TRU waste shipments assumes the use of one RH-TRU waste canister per shipment. For the Proposed Action, the number of CH-TRU waste shipments has been adjusted to the WIPP allowable volume of approximately 168,500 cubic meters (5.95 million cubic feet) rather than the 143,000 cubic meters (5 million cubic feet) shown in Table A-5.

When considering rail analysis, it was assumed that one railcar would carry six TRUPACT-IIs or two RH-72B casks, twice as much as a truck. A maximum of three railcars would be used per shipment; thus, 18 TRUPACT-IIs or six RH-72B casks could be transported per shipment.

As identified in Table A-2, certain CH-TRU waste density configurations require that waste shipments be made using only two TRUPACT-IIs rather than three. Under the Proposed Action and Action Alternative 1, about 38 percent of the TRU waste shipments would fall into this category. All of the waste shipments for Action Alternative 2 reflect two TRUPACT-IIs per shipment. Under Action Alternative 3, about 86 percent of the waste shipments would consist of two TRUPACTS-IIs rather than three.

Table A-14
TRU Waste Volumes for No Action Alternative 2 [a]

Site [b]	Site Volume Through 2033 (cubic meters)		Existing Stored Volume (cubic meters)		Newly Generated Post-Treatment Volume (cubic meters)	
	CH-TRU	RH-TRU	CH-TRU	RH-TRU	CH-TRU	RH-TRU
Hanford Site (Hanford)	57,490	29,420	12,300	200	45,190	29,200
Los Alamos National Laboratory (LANL)	21,000	230	11,050	90	9,980	130
Idaho National Engineering Laboratory (INEL) [c]	28,150	220	28,150	220	---	---
Argonne National Laboratory - West (ANL-W)	1,010	1,740	7	20	1,005	1,720
Argonne National Laboratory - East (ANL-E)	200	--- [d]	25	---	180	---
Savannah River Site (SRS)	12,070	---	2,880	---	9,180	---
Rocky Flats Environmental Technology Site (RFETS)	10,860	---	4,890	---	5,970	---
Oak Ridge National Laboratory (ORNL)	1,670	3,080	1,320	2,470	350	600
Lawrence Livermore National Laboratory (LLNL)	1,200	---	230	---	960	---
Nevada Test Site (NTS)	630	---	620	---	10	---
Mound Plant (Mound)	300	---	300	---	---	---
Bettis Atomic Power Laboratory (Bettis)	170	9	---	---	170	9
Sandia National Laboratories - Albuquerque (SNL)	17	---	7	---	10	---
Paducah Gaseous Diffusion Plant (PGDP)	8	---	---	---	8	---
U.S. Army Materiel Command (USAMC)	3	---	3	---	---	---
Energy Technology Engineering Center (ETEC)	2	7	2	6	---	1
University of Missouri Research Reactor (U of Mo)	1	---	1	---	---	---
Pantex Plant (Pantex)	1	---	1	---	1	---
Ames Laboratory - Iowa State University (Ames)	1	---	1	---	---	---
Teledyne Brown Engineering (TBE)	1	---	1	---	---	---
Battelle Columbus Laboratories (BCL)	---	580	---	590	---	---
Total	**135,000**	**35,000**	**62,000**	**3,600**	**73,000**	**32,000**

[a] The inventory for SEIS-II is based on BIR-2, which takes into account potential thermal treatment at some sites (DOE 1995d). The thermal treatment is not necessarily for PCB-commingled waste. Site volumes through 2033 are the sum of similar columns on Tables 2-2 and 2-3. Volumes have been rounded. Actual totals may differ due to rounding.
[b] Sites in boldface were included in SEIS-I.
[c] INEL and ANL-W are considered as one site in the Draft WM PEIS and, therefore, counted as one site in SEIS-II.
[d] Dashes indicate no waste.

The number of RH-TRU waste shipments from a treatment site can be calculated from the corresponding post-treatment disposal volume. The RH-TRU post-treatment disposal volumes have been calculated for the Proposed Action and each alternative, and are presented in a series of tables in this appendix. Assuming that an RH-TRU waste shipment consists of a single waste canister, the number of shipments is determined by dividing the RH-TRU post-treatment volume by 0.89 cubic meter (32 cubic feet), the volume of a single RH-TRU waste canister.

In addition to the post-treatment disposal volume, calculations for the number of CH-TRU waste shipments require the waste density of each final waste form at each treatment site. The waste density, calculated from material parameters in BIR-2, is adjusted for volume expansion to meet thermal power or PE-Ci limits, or density changes due to thermal or shred and grout treatment. The CH-TRU post-treatment disposal volumes presented in the tables within this appendix reflect site totals; they do not contain details on the final waste form by site. Average densities for each final waste form, before adjustments, are given in Tables A-16 through A-22. Waste defined as "Possible Future Wastes" in Table A-22 represents waste that would most likely be sent to WIPP. This waste was included as part of the Basic Inventory for the purpose of SEIS-II analysis.

Table A-15
Number of Truck Shipments to WIPP by Alternative [a]

Sites	Proposed Action	Action Alternative 1			Action Alternative 2A			Action Alternative 2B		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste										
Hanford	13,666	11,562	7,167	18,729	8,219	2,543	10,762	8,219	2,543	10,762
LANL	5,009	4,238	1,590	5,828	2,952	557	3,509	---	---	---
INEL	5,782	4,892	6,474	11,366	4,178	3,586	7,764	8,234	4,142	12,376
ANL-W	---	---	---	---	---	---	---	---	---	---
SRS	2,238	1,893	558	2,451	2,015	208	2,223	2,015	208	2,223
RFETS	2,485	2,102	0	2,102	1,105	0	1,105	---	---	---
ORNL	251	212	8	220	---	---	---	---	---	---
LLNL	162	137	0	137	---	---	---	---	---	---
NTS	86	73	0	73	---	---	---	---	---	---
Mound	59	50	23	73	---	---	---	---	---	---
ANL-E	28	24	0	24	---	---	---	---	---	---
Bettis	---	---	---	---	---	---	---	---	---	---
SNL	---	---	---	---	---	---	---	---	---	---
PGDP	---	---	---	---	---	---	---	---	---	---
USAMC	---	---	---	---	---	---	---	---	---	---
ETEC	---	---	---	---	---	---	---	---	---	---
U of Mo	---	---	---	---	---	---	---	---	---	---
Pantex	---	---	---	---	---	---	---	---	---	---
Ames	---	---	---	---	---	---	---	---	---	---
TBE	---	---	---	---	---	---	---	---	---	---
ARCO	---	---	---	---	---	---	---	---	---	---
LBL	---	---	---	---	---	---	---	---	---	---
WVDP	---	---	---	---	---	---	---	---	---	---
Totals	29,766	25,183	15,820	41,003	18,469	6,894	25,363	18,468	6,893	25,361
RH-TRU Waste										
Hanford	3,178	47,156	1,651	48,807	17,730	1,031	18,761	17,730	1,031	18,761
LANL	367	367	190	557	---	---	---	---	---	---
INEL	3,136	3,136	711	3,847	---	---	---	---	---	---
ORNL	1,276	5,875	3,076	8,951	2,057	1,077	3,134	2,057	1,077	3,134
Totals	7,957	56,534	5,628	62,162	19,787	2,108	21,895	19,787	2,108	21,895

[a] The transportation analysis conservatively assumes the number of rail shipments is one-half of the truck shipments.

Table A-15
Number of Truck Shipments to WIPP By Alternative-Continued [a]

Sites	Action Alternative 2C			Action Alternative 3		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste						
Hanford	11,562	7,194	18,756	24,531	8,600	33,131
LANL	4,236	1,590	5,826	7,628	1,907	9,535
INEL	4,776	6,639	11,415	10,386	7,769	18,155
ANL-W	116	0	116	---	---	---
SRS	1,893	558	2,451	2,885	706	3,591
RFETS	2,102	0	2,102	2,897	0	2,897
ORNL	192	8	200	---	---	---
LLNL	137	0	137	---	---	---
NTS	73	0	73	---	---	---
Mound	50	3	53	---	---	---
ANL-E	22	0	22	---	---	---
Bettis	20	0	20	---	---	---
SNL-AL	2	1	3	---	---	---
PGDP	1	0	1	---	---	---
USAMC	1	0	1	---	---	---
ETEC	1	0	1	---	---	---
U of Mo	1	0	1	---	---	---
Pantex	1	0	1	---	---	---
Ames	1	0	1	---	---	---
TBE	1	0	1	---	---	---
ARCO	0	1	1	---	---	---
LBL	0	1	1	---	---	---
WVDP	0	23	23	---	---	---
Totals	25,188	16,018	41,206	48,327	18,982	67,309
RH-TRU Waste						
Hanford	50,657	2,552	53,209	60,789	3,076	63,865
LANL	---	---	---	---	---	---
INEL	---	---	---	---	---	---
ORNL	5,875	3,076	8,951	7,050	3,691	10,741
Totals	56,532	5,628	62,160	67,839	6,767	74,606

[a] The transportation analysis conservatively assumes the number of rail shipments is one-half of the truck shipments.

Table A-16
CH-TRU Final Waste Form Data [a]

Site	Final Waste Form	Type[b]	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE Ci/cubic meter	Average Density (kg/cubic meter)
Ames	Solidified Inorganics	CH-MTRU	0.0	0.4	0.3668	13.7400	---	793.2
ANL-E	Lead/Cadmium Metal	CH-MTRU	1.1	1.3	---	1.0820	---	330.0
	Solidified Inorganics	CH-MTRU	5.2	0.0	0.0001	13.7400	---	355.4
	Solidified Organics	CH-MTRU	0.2	0.0	---	13.7400	---	697.2
	Uncategorized Metal	CH-TRU	5.0	128.5	0.1090	1.0820	---	302.9
ANL-W	Combustible	CH-MTRU	0.0	2.0	0.2609	0.5413	7.85	401.2
	Heterogeneous	CH-MTRU	1.7	0.0	0.0648	0.5413	1.77	512.3
	Combustible	CH-TRU	0.0	99.6	---	0.5413	---	401.2
	Heterogeneous	CH-TRU	4.8	345.4	---	0.5413	---	512.3
	Uncategorized Metal	CH-TRU	0.0	293.8	---	1.0820	---	423.7
Bettis	Heterogeneous	CH-TRU	0.0	123.3	0.3782	0.5413	0.04	332.7
ETEC	Heterogeneous	CH-TRU	1.7	0.0	---	0.5413	0.14	512.3
Hanford	Combustible	CH-MTRU	455.7	1,247.3	0.2288	0.5413	8.06	133.9
	Lead/Cadmium Metal	CH-MTRU	14.2	34.5	0.1391	1.0820	4.90	328.2
	Solidified Organics	CH-MTRU	7.4	9.4	0.1315	13.7400	4.63	160.7
	Uncategorized Metal	CH-MTRU	444.9	19,635.2	0.1971	1.0820	0.14	419.4
	Heterogeneous,	CH-TRU	11,190.8	6,271.3	0.3931	0.5413	8.91	865.5
	Inorganic Non-Metal	CH-TRU	34.7	69.1	0.1466	1.0820	5.28	204.7
	Soils	CH-TRU	119.5	5,961.7	1.4339	13.7400	1.08	635.7
	Solidified Inorganics	CH-TRU	12.9	7.1	0.1423	13.7400	4.90	432.5
INEL	Filter	CH-MTRU	131.0	0.0	0.9120	0.5413	27.72	96.6
	Inorganic Non-Metal	CH-MTRU	2,066.1	0.0	0.5747	1.0820	18.05	1,827.6
	Solidified Organics	CH-MTRU	789.7	0.0	0.0620	13.7400	2.12	894.9
	Inorganic Non-Metal	CH-TRU	853.6	0.0	0.4966	1.0820	---	2,463.3
	Combustible	CH-MTRU	3,239.2	0.0	0.0936	0.5413	2.96	725.8
	Graphite	CH-MTRU	410.6	0.0	0.1647	1.0820	5.71	310.9
	Heterogeneous	CH-MTRU	6,334.2	0.0	0.0755	0.5413	1.97	415.5
	Lead/Cadmium Metal	CH-MTRU	14.4	0.0	---	1.0820	---	313.5
	Salt	CH-MTRU	8.8	0.0	4.5238	13.7400	142.63	203.6
	Solidified Inorganics	CH-MTRU	3,991.7	0.0	0.5209	13.7400	15.80	674.6
	Uncategorized Metal	CH-MTRU	5,789.8	0.0	0.2055	1.0820	5.88	306.3
	Combustible	CH-TRU	65.8	0.0	3.0165	0.5413	76.67	280.3
	Graphite	CH-TRU	87.6	0.0	0.3372	1.0820	11.61	338.8
	Heterogeneous	CH-TRU	4,274.3	0.0	0.0633	0.5413	0.40	318.1
	Salt	CH-TRU	11.7	0.0	1.3889	13.7400	37.33	318.3
	Uncategorized Metal	CH-TRU	77.1	0.0	10.7713	1.0820	88.22	403.6
LANL	Combustible	CH-MTRU	266.3	698.9	0.7201	0.5413	20.90	354.1
	Solidified Inorganics	CH-MTRU	4,883.2	1,952.3	1.2818	13.7400	17.02	1,248.3
	Uncategorized Metal	CH-MTRU	2,561.9	1,118.2	0.3720	1.0820	12.14	417.7
	Combustible	CH-TRU	1,555.2	1,677.3	1.1597	0.5413	35.73	354.1
	Heterogeneous	CH-TRU	16.0	29.1	0.0529	0.5413	7.99	346.3
	Soils	CH-TRU	110.6	29.1	0.0706	13.7400	1.98	1,200.0
	Solidified Inorganics	CH-TRU	5.0	81.5	4.0527	13.7400	111.66	1,004.8
	Solidified Organics	CH-TRU	1.5	29.1	0.1459	13.7400	4.49	1,296.0
	Uncategorized Metal	CH-TRU	1,652.5	1,735.6	1.1597	1.0820	32.38	525.0

[a] Dashed line indicates that information was not available

[b] MTRU denotes TRU mixed waste

Table A-16
CH-TRU Final Waste Form Data-Continued [a]

Site	Final Waste Form	Type[b]	Stored Volume (cubic meter)	Projected Volume (cubic meter)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE Ci/cubic meter	Average Density (kg/cubic meter)
LLNL	Heterogeneous	CH-MTRU	8.6	0.0	0.2682	0.5413	4.45	221.3
	Solidified Organics	CH-MTRU	1.0	5.8	0.0872	13.7400	3.08	268.0
	Filter	CH-TRU	15.5	32.3	0.1801	0.5413	3.36	213.9
	Heterogeneous	CH-TRU	190.2	663.8	0.1269	0.5413	4.36	165.3
	Salt	CH-TRU	0.6	3.0	0.2268	13.7400	7.94	342.0
	Solidified Inorganics	CH-TRU	14.4	5.8	0.0939	13.7400	3.31	268.0
Mound	Combustible	CH-MTRU	1.7	0.0	3.1350	0.5413	86.97	401.2
	Solidified Inorganics	CH-MTRU	1.9	0.0	0.2405	13.7400	6.60	1,074.6
	Combustible	CH-TRU	5.4	0.0	3.0542	0.5413	83.90	401.2
	Filter	CH-TRU	0.8	0.0	0.0653	0.5413	1.55	96.0
	Heterogeneous	CH-TRU	0.6	0.0	0.9581	0.5413	27.80	512.3
	Soils	CH-TRU	177.2	0.0	0.0076	13.7400	0.22	846.8
	Solidified Inorganics	CH-TRU	4.2	0.0	0.0040	13.7400	0.11	1,143.0
	Uncategorized Metal	CH-TRU	82.5	0.0	0.1613	1.0820	3.86	423.7
NTS	Heterogeneous	CH-MTRU	613.3	9.0	0.1667	0.5413	5.29	225.2
	Solidified Inorganics	CH-TRU	5.7	0.0	0.2243	13.7400	7.78	272.0
ORNL	Heterogeneous	CH-MTRU	697.6	256.3	0.0051	0.5413	0.15	251.8
	Heterogeneous	CH-TRU	606.5	0.0	0.0633	0.5413	1.89	251.8
Pantex	Heterogeneous	CH-TRU	0.6	0.0	0.2369	0.5413	---	109.6
PGDP	Inorganic Non-Metal	CH-MTRU	0.0	1.9	0.0031	1.0820	0.08	63.6
RFETS	Combustible	CH-MTRU	151.4	736.5	0.0908	0.5413	3.00	131.2
	Filter	CH-MTRU	2.1	325.4	0.1273	0.5413	4.42	84.9
	Heterogeneous	CH-MTRU	1.2	0.0	0.0232	0.5413	0.81	362.0
	Inorganic Non-Metal	CH-MTRU	16.5	291.7	0.0499	1.0820	1.73	249.8
	Lead/Cadmium Metal	CH-MTRU	4.0	298.3	0.1349	1.0820	4.41	245.2
	Solidified Inorganics	CH-MTRU	150.2	1,193.3	0.0894	13.7400	0.56	714.9
	Solidified Organics	CH-MTRU	109.8	0.0	0.0276	13.7400	1.33	983.5
	Uncategorized Metal	CH-MTRU	1.5	0.0	0.8873	1.0820	30.47	215.5
	Combustible	CH-TRU	34.1	124.6	0.0668	0.5413	2.16	79.5
	Filter	CH-TRU	70.0	152.2	0.2361	0.5413	8.15	90.5
	Graphite	CH-TRU	13.7	47.6	0.2060	1.0820	7.17	279.1
	Heterogeneous	CH-TRU	2.6	0.0	0.0232	0.5413	0.19	370.8
	Inorganic Non-metal	CH-TRU	41.8	575.0	0.0836	1.0820	2.90	219.0
	Salt	CH-TRU	0.0	325.9	---	13.7400	---	536.4
	Solidified Inorganics	CH-TRU	15.2	64.3	1.1542	13.7400	39.53	685.4
	Solidified Organics	CH-TRU	0.0	31.1	0.0701	13.7400	2.44	349.1
	Uncategorized Metal	CH-TRU	91.9	236.1	0.0836	1.0820	2.89	321.3
SNL	Heterogeneous	CH-TRU	6.7	7.5	0.0522	0.5413	0.94	166.1
SRS	Heterogeneous	CH-MTRU	2,611.6	5,465.2	2.9701	0.5413	83.78	173.2
	Solidified Inorganics	CH-MTRU	200.2	1,169.6	1.7429	13.7400	48.26	2,185.5
	Uncategorized Metal	CH-MTRU	70.4	120.5	2.9701	1.0820	83.78	387.1
	Heterogeneous	CH-TRU	0.0	10.7	3.0504	0.5413	83.64	161.5
TBE	Inorganic Non-Metal	CH-TRU	0.2	0.0	0.0171	1.0820	0.55	327.0
U of Mo	Heterogeneous	CH-MTRU	0.2	0.8	0.0513	0.5413	1.54	101.3
USAMC	Heterogeneous	CH-TRU	2.5	0.0	0.0028	0.5413	0.09	512.3

[a] Dashed line indicates that information was not available

[b] MTRU denotes TRU mixed waste

Table A-17
RFETS Residue Data CH-TRU Final Waste Form Data [a, b]

Final Waste Form	Type	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
Combustible	CH-TRU	184.4	0.0	2.5205	0.5413	17.34	---[b]
Filter	CH-TRU	592.8	0.0	2.5205	0.5413	17.34	---
Graphite	CH-TRU	47.1	0.0	2.5205	1.0820	17.34	---
Heterogeneous	CH-TRU	3.8	0.0	2.5205	0.5413	17.34	---
Inorganic Non-Metal	CH-TRU	2,509.6	0.0	2.5205	1.0820	17.34	---
Lead/Cadmium Metal	CH-TRU	7.6	0.0	2.5205	1.0820	17.34	---
Salt	CH-TRU	376.5	0.0	2.5205	13.7400	17.34	---
Solidified Inorganics	CH-TRU	404.6	0.0	2.5205	13.7400	17.34	---
Uncategorized Metal	CH-TRU	55.5	0.0	2.5205	1.0820	17.34	---

[a] RFETS residue data is part of the Basic Inventory
[b] Dashed line indicates that information was not available

Table A-18
PCB-Commingled TRU Final Waste Form Data [a]

Site	Final Waste Form	Type[b]	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
Hanford	Uncategorized Metal	CH-MTRU	66.1	113.4	---	---	---	255.7
	Lead/Cadmium Metal	CH-MTRU	3.8	0.0	---	---	---	327.9
	Solidified Organics	CH-MTRU	2.1	8.3	---	---	---	160.4
	Solidified Organics	CH-MTRU	1.2	2.5	---	---	---	153.2
	Uncategorized Metal	CH-MTRU	0.2	0.0	---	---	---	338.1
INEL	Inorganic Non-Metal	CH-MTRU	108.6	0.0	---	---	---	2,500.0
	Solidified Organics	CH-MTRU	352.8	0.0	---	---	---	903.9
Mound	Unknown	CH-TRU	19.0	0.0	---	---	---	---
	Unknown	CH-TRU	0.2	0.0	---	---	---	---

[a] Dashed line indicates that information was not available
[b] MTRU denotes TRU mixed waste

Calculating the number of CH-TRU shipments from a site begins with the post-treatment disposal volume of a final waste form. From this, the number of drums is determined using the assumption that the volume of each drum is 0.208 cubic meter (7.3 cubic feet). Next, the adjusted waste density is used to determine the number of drums that can be moved in one shipment (Table A-2). The process is repeated for each final waste form at the treatment site. The result is the total number of waste shipments from the treatment site.

Table A-19
RH-TRU Final Waste Form Data [a]

Site	Final Waste Form	Type[b]	Stored Volume (cubic meters	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
ANL-W	Inorganic Nonmetal	RH-MTRU	0.0	21.4	---	337.1	---	132.5
	Solidified Inorganics	RH-MTRU	1.8	28.5	---	337.1	---	1,074.6
	Heterogeneous	RH-TRU	0.0	1,208.6	---	337.1	---	512.3
	Lead/Cadmium Metal	RH-TRU	0.0	6.2	---	337.1	---	423.7
BCL	Heterogeneous	RH-TRU	580.5	0.0	---	337.1	0.01	2,000.0
Bettis	Heterogeneous	RH-TRU	0.0	6.7	6.3620	337.1	45.45	885.0
ETEC	Lead/Cadmium Metal	RH-MTRU	0.9	0.0	---	337.1	13.19	313.5
Hanford	Heterogeneous	RH-MTRU	0.0	2,617.5	---	337.1	---	432.4
	Lead/Cadmium Metal	RH-MTRU	2.7	60.5	0.0012	337.1	0.06	592.0
	Uncategorized Metal	RH-MTRU	0.0	0.0	0.0003	337.1	0.00	519.1
	Heterogeneous	RH-TRU	199.4	1,448.9	1.9994	337.1	0.61	460.2
	Uncategorized Metal	RH-TRU	0.0	17,400.4	0.0003	337.1	0.00	283.5
INEL	Combustible	RH-MTRU	21.4	0.0	0.2655	337.1	9.17	294.0
	Heterogeneous	RH-MTRU	43.9	0.0	0.1421	337.1	4.82	210.3
	Inorganic Non-Metal	RH-MTRU	33.2	0.0	1.2867	337.1	39.34	1,930.6
	Lead/Cadmium Metal	RH-MTRU	3.6	0.0	---	337.1	---	313.5
	Solidified Inorganics	RH-MTRU	65.3	0.0	0.6192	337.1	18.68	466.1
	Solidified Organics	RH-MTRU	3.6	0.0	0.5015	337.1	17.04	842.1
	Uncategorized Metal	RH-MTRU	22.5	0.0	0.0672	337.1	2.34	221.4
	Heterogeneous	RH-TRU	5.9	0.0	0.0048	337.1	0.09	378.2
	Inorganic Non-Metal	RH-TRU	13.1	0.0	4.4674	337.1	39.85	2,500.0
	Uncategorized Metal	RH-TRU	8.3	0.0	22.2868	337.1	204.34	341.5
LANL	Uncategorized Metal	RH-MTRU	16.9	33.8	0.9587	337.1	9.57	557.5
	Combustible	RH-TRU	15.1	49.0	0.1466	337.1	2.92	354.1
	Heterogeneous	RH-TRU	11.6	0.0	0.1990	337.1	3.17	302.9
	Uncategorized Metal	RH-TRU	50.7	16.0	0.0002	337.1	0.00	567.4
ORNL	Heterogeneous	RH-MTRU	1,347.5	240.3	0.0005	337.1	0.01	251.8
	Solidified Inorganics	RH-MTRU	1,036.9	206.5	---	337.1	0.01	793.3
	Heterogeneous	RH-TRU	84.5	0.0	0.0107	337.1	0.09	251.8

[a] Dashed line indicates that information was not available
[b] MTRU denotes TRU mixed waste

A.3.10 Final Waste Form Data

The data from which the volume, density, and PE-Ci results were derived are presented in Table A-16. Cells with dashed lines indicate that BIR-2 data were not available to calculate the values. Where thermal power or PE-Ci data were missing, it was assumed that the waste form met planning-basis WAC requirements without volume expansion. When density data were missing, it was assumed that a CH-TRU shipment can handle three fully loaded TRUPACT-II's, except under Action Alternative 2 where a shipment consists of 12 drums and an RH-TRU shipment can handle three drums.

Table A-20
Previously Disposed TRU Final Waste Form Data [a]

Site	Final Waste Form	Type	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
Hanford	Buried	CH-TRU	62,599.1	0.0	---	---	---	---
Hanford	Buried	RH-TRU	1,029.9	0.0	---	---	---	---
INEL	Buried	CH-TRU	56,556.5	0.0	---	---	---	---
INEL	Buried	RH-TRU	443.5	0.0	---	---	---	---
LANL	Buried	CH-TRU	13,881.5	0.0	---	---	---	---
LANL	Buried	RH-TRU	118.5	0.0	---	---	---	---
ORNL	Buried	CH-TRU	60.8	0.0	---	---	---	---
ORNL	Buried	RH-TRU	115.2	0.0	---	---	---	---
SNL	Buried	CH-TRU	1.3	0.0	---	---	---	---
SRS	Buried	CH-TRU	4,874.0	0.0	---	---	---	---
WVDP	Unknown, Buried Assume RH-TRU	RH-TRU	1,353.2	0.0	---	---	---	---

[a] Dashed line indicates that information was not available

A.4 RADIONUCLIDE INVENTORY

Risk analyses require knowing the radionuclide inventory at each site as well as the combined amounts of each radionuclide that would be disposed of at WIPP.

The WIPP facility has been designed with the intent to use it for disposal of TRU waste. TRU wastes are defined to be wastes containing more than 100 nanocuries of alpha-emitting TRU radionuclides per gram of waste, with half-lives greater than 20 years, subject to a number of conditions (see Chapter 1). TRU waste at the generator-storage sites typically include non-TRU radionuclides commingled with the TRU waste. Data on all of the radionuclides are presented in this appendix. The four non-TRU radionuclides with the greatest activity in the waste are strontium-90 (Sr-90), yttrium-90 (Y-90), cesium-137 (Cs-137), and barium-137m (Ba-137m).

A.4.1 Inventory Information in 1995

The radionuclide activity by site was obtained from IDB (DOE 1994a), and the activity was adjusted to account for decay to December 31, 1995. Radionuclide information for CH-TRU waste was available for the following sites: Argonne National Laboratory-East (ANL-E), ARCO, U.S. Army Materiel Command (USAMC), Energy Technical Engineering Center (ETEC), Hanford, INEL, LBL, Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), Mound, University of Missouri (U of Mo), Nevada Test Site (NTS), ORNL, Paducah Gaseous Diffusion Plant (PGDP), Pantex Plant (Pantex), and RFETS. More than 99 percent of the CH-TRU waste volume in the Basic Inventory is located at these sites.

Table A-21
Commercial/Nondefense TRU Final Waste Form Data [a]

Site	Final Waste Form	Type[b]	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
LBL	Heterogeneous	CH-TRU	0.6	1.0	---	---	---	1,565.0
ORNL	Heterogeneous	CH-MTRU [b]	1.0	0.0	---	---	---	251.8
	Unknown	CH-TRU	4.4	0.0	---	---	---	251.8
Knolls	Heterogeneous	RH-TRU	2.5	51.0	---	---	---	252.9
	Heterogeneous	RH-MTRU	0.0	6.9	---	---	---	253.8
ARCO	Heterogeneous	CH-TRU	0.2	0.2	---	---	---	---
WVDP	Unknown	CH-MTRU	10.0	0.0	---	---	---	---
	Solidified Inorganics	CH-TRU	0.2	0.0	---	---	---	---
	Solidified Inorganics	CH-TRU	0.4	0.0	---	---	---	---
	Unknown	CH-TRU	0.2	0.0	---	---	---	---
	Solidified Inorganics	CH-MTRU	1.5	0.0	---	---	---	---
	Heterogeneous	CH-TRU	3.7	0.0	---	---	---	---
	Unknown	CH-TRU	0.6	0.0	---	---	---	---
	Inorganic Non-Metal	CH-TRU	0.2	0.0	---	---	---	---
	Unknown	CH-TRU	0.4	0.0	---	---	---	---
	Heterogeneous	CH-TRU	13.0	88.0	---	---	---	---
	Heterogeneous	CH-TRU	2.1	29.1	---	---	---	---
	Uncategorized Metal	CH-TRU	0.2	0.0	---	---	---	---
	Lead/Cadmium Metal	CH-MTRU	2.1	0.0	---	---	---	---
	Solidified Organics	CH-MTRU	0.4	0.0	---	---	---	---
	Filter	RH-TRU	3.8	0.0	---	---	---	---
	Filter	RH-TRU	49.0	46.0	---	---	---	---
	Unknown	RH-TRU	17.8	0.0	---	---	---	---
	Uncategorized Metal	RH-TRU	89.9	0.0	---	---	---	---

[a] Dashed line indicates that information was not available
[b] MTRU denotes TRU mixed waste

RH-TRU waste radionuclide information was only available from the following sites: ETEC, Hanford, INEL, LANL, NTS, ORNL. In the Basic Inventory, approximately 98 percent of the RH-TRU waste volume is located at these sites.

The percentages of RH-TRU waste volumes at these sites in the Total Inventory for Action Alternatives 1, 2, 3, No Action Alternative 1, and No Action Alternative 2 are 93, 84, 93, 81, and 94 percent, respectively. Most of the remaining RH-TRU waste volume is accounted for at Battelle-Columbus; however, no information was available for this site.

Table A-22
Possible Future TRU Final Waste Form Data [a, b]

Site	Final Waste Form	Type[c]	Stored Volume (cubic meters)	Projected Volume (cubic meters)	Thermal Power Loading (W/cubic meter)	Thermal Power Limit Bagless (W/cubic meter)	PE-Ci/cubic meter	Average Density (kg/cubic meter)
ANL-E	Uncategorized - Unknown	CH-TRU	13.3	0.0	---	---	---	---
ETEC	Uncategorized - Unknown	RH-MTRU	5.4	0.8	---	---	---	---
Mound	Uncategorized - Unknown	CH-TRU	23.0	0.0	---	---	---	---
	Uncategorized - Unknown	CH-TRU	4.2	0.0	---	---	---	---
ORNL	Uncategorized - Unknown	CH-TRU	17.7	0.0	---	---	---	---
	Uncategorized - Unknown	RH-TRU	0.9	0.0	---	---	---	---
PGDP	Uncategorized - Unknown	CH-MTRU	0.0	1.9	---	---	---	---
	Uncategorized - Unknown	CH-MTRU	0.0	1.9	---	---	---	---
Hanford	Uncategorized - Unknown	CH-MTRU	0.4	0.0	---	---	---	---
	Uncategorized - Unknown	CH-MTRU	0.2	0.0	---	---	---	---
	Uncategorized - Unknown	CH-TRU	0.2	0.0	---	---	---	---
	Uncategorized - Unknown	CH-TRU	1.5	0.8	---	---	---	---
	Uncategorized - Unknown	CH-TRU	19.0	61.0	---	---	---	---
	Uncategorized - Unknown	CH-TRU	0.4	0.0	---	---	---	---

[a] Dashed line indicates that information was not available
[b] This waste volume has been included as part of the Basic Inventory
[c] MTRU denotes TRU mixed waste

Four sites provided RH-TRU waste radionuclide information in the IDB but not in BIR-2. These sites were: NTS, ANL-E, SRS, and Sandia National Laboratories (SNL). These sites were not identified as having RH-TRU waste in BIR-2.

Due to a lack of radionuclide information for some waste streams in BIR-2, site radionuclide information for all but RFETS and ORNL were obtained from IDB. RFETS residue data were only found in BIR-2 and, therefore, were added to RFETS IDB data. ORNL's CH-TRU data for Cs-137 and Ba-137m radionuclide concentrations in the IDB were found to exceed the 200 millirem per hour limit to be designated as CH-TRU waste. Likewise, the data in BIR-2 for ORNL exceeded this limit. As an example, waste stream OR-W044 reported 520 cubic meters (18,360 cubic feet) of waste with a concentration of 0.489 Ci per cubic meter. ORNL staff confirmed that only 13 drums (2.704 cubic meters [95 cubic feet]) within this waste stream have the 0.489 Ci per cubic meter concentration, and yet it was applied to the entire waste stream. SEIS-II uses the Cs-137 data from BIR-2 rather than from IDB. OR-W044 waste stream data were adjusted to show Cs-137 in only 13 drums (2.704 cubic meters [95 cubic feet]). Under these assumptions, a total stored inventory of 1.328 Ci for Cs-137 and about 1.256 Ci for Ba-137m were determined.

The radionuclide inventories for stored CH-TRU and RH-TRU waste in 1995 according to generator-storage site are given in Tables A-23 and A-24, respectively.

The site radionuclide information represents the radionuclide inventory in a given volume as determined from IDB or BIR-2. The radionuclide inventory by site for an alternative was calculated using the following equation:

$$I_{Alternative} = I_{1995} + \left(\frac{I_{1995}}{V_{IDB}}\right)(V_{Estimated} - V_{Stored}) \qquad \text{(Equation A-7)}$$

where

$I_{Alternative}$ = total site radionuclide inventory (in Ci) used in the analysis for an alternative

I_{1995} = inventory in 1995 from IDB

V_{IDB} = volume associated with I_{1995}

$V_{Estimated}$ = estimated volume from Tables 2-2 and 2-3 to be generated through 2033 for an alternative

V_{Stored} = stored, post-treatment 1995 volume based on Tables 2-2 and 2-3.

V_{factor} = complex volume variable used to estimate the total site radionuclide inventory for each alternative

Rearranging terms, this equation can be written as:

$$I_{Alternative} = I_{1995}\left[1 + \left(\frac{V_{Estimated} - V_{Stored}}{V_{IDB}}\right)\right] \text{ or}$$

$$I_{Alternative} = I_{1995}\, V_{factor} \qquad \text{(Equation A-8)}$$

CH-TRU waste volume factors (V_{Factor}) are presented in Table A-25. To meet the LWA limit of 168,500 cubic meters (5.95 million cubic feet), radionuclide activity was adjusted by a factor of approximately 1.182 under the Proposed Action. Likewise, CH-TRU waste volume factors for the Proposed Action were adjusted by this factor. Because volume factors are determined according to waste treatment site, and do not depend upon which wastes are included at WIPP, or how wastes are treated prior to disposal, the volume factors among the Draft WM PEIS regionalized options within an alternative are the same. Those sites without radionuclide inventory estimates in IDB were not included in the table.

Table A-23
Radionuclide Inventories (Ci) for Stored CH-TRU Waste in 1995

Isotope	ANL-E	ARCO	USAMC	ETEC	Hanford	INEL	LBL	LANL	LLNL	MOUND	U of MO	NTS	ORNL	PGDP	Pantex	RFETS	RFETS Residues	SRS	Total
Pu-238	2.11E+00	3.70E+02	---	1.11E-01	8.05E+04	5.98E+04	2.32E-04	1.15E+05	7.65E+01	4.97E+02	---	3.15E+04	3.50E+03	---	---	3.43E+02	8.14E+03	5.53E+05	8.52E+05
Pu-241	5.43E+01	---	---	6.22E+00	3.78E+04	1.50E+05	4.48E-07	1.62E+03	1.63E+03	---	6.32E-03	2.40E+02	4.79E+04	---	---	5.23E+04	1.02E+06	1.12E+05	1.42E+06
Pu-239	3.28E+01	---	1.80E+01	1.79E+00	2.63E+04	4.01E+04	8.45E-06	7.91E+04	1.64E+02	6.28E+00	2.46E-02	2.76E+03	2.72E+03	5.57E+01	5.55E-02	9.98E+03	1.74E+05	9.35E+03	3.44E+05
Am-241	5.89E+00	---	---	5.19E-01	4.73E+03	9.01E+04	9.17E-02	1.17E+04	1.44E+02	---	3.24E-01	2.84E+02	1.61E+03	---	---	1.10E+04	1.09E+05	2.01E+03	2.30E+05
Pu-240	9.42E+00	---	---	6.12E-01	6.14E+03	9.84E+03	5.14E-03	1.01E+02	6.44E+01	---	---	2.66E+01	9.48E+02	---	---	7.22E+03	3.98E+04	2.31E+03	6.64E+04
Cs-137	---	---	---	---	6.83E+02	6.04E+01	---	4.81E+01	1.66E-06	---	---	3.60E-01	1.33E+00	---	---	---	---	7.51E+00	8.01E+02
Ba-137m	---	---	---	---	6.46E+02	5.71E+01	---	4.55E+01	1.57E-06	---	---	3.41E-01	1.26E+00	---	---	---	---	7.11E+00	7.57E+02
Cm-244	---	---	---	---	6.83E+01	4.93E+02	8.70E-02	1.56E+02	6.54E+01	---	---	2.28E+02	1.06E+03	---	---	---	---	1.17E+03	3.24E+03
Y-90	---	---	---	2.00E-01	6.92E+02	1.96E+00	---	4.44E+01	---	---	---	3.10E-01	1.48E+03	---	---	---	---	6.98E+00	2.22E+03
Sr-90	---	---	---	2.00E-01	6.92E+02	1.96E+00	---	4.44E+01	---	---	---	3.10E-01	1.48E+03	---	---	---	---	6.98E+00	2.22E+03
U-233	3.00E-02	---	---	1.20E-11	8.00E+01	8.99E+02	4.81E-03	4.46E+01	5.95E-09	---	1.78E-09	1.81E+00	1.77E+02	1.42E-03	---	1.29E+01	---	3.75E+00	1.22E+03
Pu-242	1.00E-02	---	---	5.00E-05	3.80E-01	9.45E-01	1.01E-02	4.85E+02	2.02E-02	---	---	8.70E-02	2.37E-01	---	---	9.63E-05	---	3.75E-01	4.87E+02
U-234	---	1.05E-03	---	1.93E-06	5.37E+01	6.18E+00	4.73E-09	6.06E+00	3.29E-03	2.47E-02	2.98E-13	1.26E-02	1.57E+01	---	---	4.81E-03	---	2.56E+01	1.07E+02
Pa-233	---	---	---	9.49E-07	2.72E-01	8.53E-01	6.32E-06	3.22E-02	4.71E-04	---	2.28E-04	5.78E-03	7.32E-01	5.50E+01	---	1.70E-02	---	8.59E+00	6.55E+01
Np-237	---	---	---	9.49E-07	2.72E-01	8.53E-01	6.32E-06	3.22E-02	4.71E-04	---	2.28E-04	5.78E-03	7.27E-01	5.50E+01	---	1.70E-02	---	8.59E+00	6.55E+01
Co-60	---	---	---	---	---	6.24E+01	---	7.91E-06	---	---	---	---	1.84E-06	---	---	---	---	3.56E-01	6.28E+01
Eu-155	---	---	---	---	1.06E-03	3.83E-01	---	2.41E-01	---	---	---	3.80E-03	---	---	---	---	---	5.28E+01	5.34E+01
Cf-252	---	---	---	---	3.52E+01	2.19E-03	---	---	---	---	---	1.70E-02	1.60E-01	---	---	---	---	3.62E-01	3.58E+01
Pb-212	---	---	---	---	5.18E-02	2.62E+01	---	6.16E-03	---	---	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Ra-224	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---	---	1.71E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Bi-212	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Po-216	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Rn-220	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
Th-228	---	---	---	---	5.18E-02	2.62E+01	---	1.32E-03	---	---	---	1.64E-02	2.83E-01	---	---	---	---	9.20E-03	2.66E+01
U-232	---	---	---	---	---	2.53E+01	---	1.67E-03	---	---	---	1.65E-02	2.90E-01	---	---	---	---	8.94E-02	2.57E+01
Np-239	9.52E-02	---	---	---	9.01E-02	3.79E-01	3.85E-02	3.83E+00	2.45E-02	---	---	1.22E+00	1.49E+01	---	---	---	---	7.55E-01	2.13E+01
Am-243	9.52E-02	---	---	---	9.01E-02	3.79E-01	3.85E-02	3.83E+00	2.45E-02	---	---	1.22E+00	1.16E+01	---	---	---	---	7.55E-01	1.81E+01
Tc-99	---	---	---	---	9.51E-06	2.16E-03	---	1.02E-02	---	---	---	5.99E-05	1.78E+01	---	---	---	---	4.50E-06	1.78E+01
Po-212	---	---	---	---	3.32E-02	1.68E+01	---	8.48E-04	---	---	---	1.05E-02	1.82E-01	---	---	---	---	5.89E-03	1.70E+01
Cm-245	---	---	---	---	1.68E+01	9.09E-06	2.27E-06	1.60E-06	---	---	---	9.44E-06	3.35E-05	---	---	---	---	---	1.68E+01
Tl-208	---	---	---	---	1.86E-02	9.42E+00	---	4.76E-04	---	---	---	5.89E-03	1.02E-01	---	---	---	---	3.31E-03	9.55E+00
U-237	---	---	---	1.53E-04	9.27E-01	3.67E+00	---	3.98E-02	4.00E-02	---	1.55E-07	5.88E-03	1.18E+00	---	---	1.28E+00	---	1.52E+00	8.66E+00
Ra-226	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.05E-01	3.99E-08	4.47E-09	---	2.50E-01	6.54E+00	---	---	---	---	7.30E-06	7.77E+00
Po-218	---	---	1.40E-11	---	3.15E-05	4.80E-02	3.37E-02	9.05E-01	---	4.47E-09	---	2.50E-01	6.49E+00	---	---	---	---	7.30E-06	7.73E+00
Rn-222	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.05E-01	---	4.47E-09	---	2.50E-01	6.49E+00	---	---	---	---	7.30E-06	7.73E+00

Table A-23
Radionuclide Inventories (Ci) for Stored CH-TRU Waste in 1995-Continued

Isotope	ANL-E	ARCO	USAMC	ETEC	Hanford	INEL	LBL	LANL	LLNL	MOUND	U of MO	NTS	ORNL	PGDP	Pantex	RFETS	RFETS Residues	SRS	Total
Bi-214	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.04E-01	---	4.46E-09	---	2.49E-01	6.49E+00	---	---	---	---	7.30E-06	7.72E+00
Pb-214	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.04E-01	---	4.46E-09	---	2.49E-01	6.49E+00	---	---	---	---	7.30E-06	7.72E+00
Po-214	---	---	---	---	3.15E-05	4.80E-02	3.37E-02	9.04E-01	---	4.46E-09	---	2.49E-01	6.49E+00	---	---	---	---	7.30E-06	7.72E+00
Ag-109m	---	---	---	---	---	---	---	6.56E+00	---	---	---	---	---	---	---	---	---	---	6.56E+00
Cd-109	---	---	---	---	---	---	---	6.55E+00	---	---	---	---	---	---	---	---	---	---	6.55E+00
Pa-234m	---	---	---	---	5.86E+00	1.16E-01	---	2.38E-02	3.03E-02	---	1.16E-07	3.46E-04	4.26E-02	---	---	---	---	5.71E-03	6.08E+00
Th-234	---	---	---	---	5.86E+00	1.16E-01	---	2.36E-02	3.03E-02	---	1.16E-07	3.18E-04	4.26E-02	---	---	---	---	5.71E-03	6.08E+00
U-238	---	---	---	---	5.86E+00	1.16E-01	---	2.36E-02	3.03E-02	---	1.16E-07	1.64E-04	4.26E-02	---	---	---	---	5.71E-03	6.08E+00
Pm-147	---	---	---	---	4.78E-02	2.62E+00	---	2.00E+00	---	---	---	1.05E-01	1.94E-02	---	---	---	---	1.24E-05	4.80E+00
U-235	---	---	1.77E-08	1.06E-08	1.71E+00	6.18E-02	---	5.27E-01	5.93E-04	1.05E-07	4.44E-11	1.17E-02	1.33E-02	3.29E-07	1.09E-10	4.78E-05	---	5.84E-03	2.33E+00
Th-231	---	---	1.77E-08	1.06E-08	1.71E+00	6.18E-02	---	5.27E-01	1.76E-03	1.05E-07	3.75E-08	6.15E-05	1.45E-02	3.29E-07	1.09E-10	4.78E-05	---	5.84E-03	2.32E+00
Ac-225	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Th-229	---	---	---	---	1.31E-01	1.52E+00	5.75E-06	8.06E-02	---	---	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Ra-225	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---	---	2.41E-03	2.07E-01	4.02E-07	4.02E-07	---	---	1.31E-05	1.94E+00
At-217	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Bi-213	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Fr-221	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Pb-209	---	---	---	---	1.31E-01	1.52E+00	5.45E-06	8.06E-02	---	---	---	2.41E-03	2.07E-01	4.02E-07	---	---	---	1.31E-05	1.94E+00
Po-213	---	---	---	---	1.28E-01	1.49E+00	5.33E-06	7.89E-02	---	---	---	2.36E-03	2.02E-01	3.93E-07	---	---	---	1.28E-05	1.90E+00
C-14	---	---	---	---	1.60E+00	1.66E-01	---	2.00E-07	---	---	---	2.50E-04	---	---	---	---	---	---	1.77E+00
Bi-210	---	---	---	---	5.30E-06	2.70E-02	8.96E-03	2.80E-01	---	5.20E-10	---	6.69E-02	1.26E+00	---	---	---	---	1.11E-06	1.65E+00
Po-210	---	---	---	---	5.30E-06	2.70E-02	8.96E-03	2.80E-01	---	5.20E-10	---	6.69E-02	1.26E+00	---	---	---	---	1.11E-06	1.65E+00
Pb-210	---	---	---	---	5.30E-06	2.70E-02	8.96E-03	2.80E-01	---	5.20E-10	---	6.69E-02	1.26E+00	---	---	---	---	1.11E-06	1.65E+00
Eu-152	---	---	---	---	7.34E-07	1.62E-01	---	4.18E-04	1.33E-06	---	---	1.06E+00	6.18E-04	---	---	---	---	---	1.22E+00
Cm-243	---	---	---	---	1.52E-02	---	---	1.11E+00	---	---	---	---	---	---	---	---	---	---	1.12E+00
Eu-154	---	---	---	---	6.22E-05	6.43E-01	---	2.45E-02	5.25E-07	---	---	4.28E-01	---	---	---	---	---	2.84E-04	1.10E+00

Table A-24
Radionuclide Inventories (Ci) for Stored RH-TRU Waste in 1995 [a]

Isotope	ETEC	Hanford	INEL	KAPL	LANL	ORNL	WVDP	TOTAL
Y-90	2.62E+00	6.46E+03	1.70E+03	5.70E+01	1.24E+02	3.52E+04	1.96E+01	4.36E+04
Sr-90	2.62E+00	6.46E+03	1.70E+03	5.70E+01	1.24E+02	3.52E+04	1.96E+01	4.36E+04
Cs-137	2.62E+00	6.98E+03	1.90E+03	5.71E+01	1.35E+02	9.78E+03	5.35E+01	1.89E+04
Ba-137m	2.48E+00	6.61E+03	1.80E+03	5.40E+01	1.28E+02	9.25E+03	5.06E+01	1.79E+04
Pu-241	---	4.67E+03	4.81E+01	7.77E-01	---	3.97E-07	---	4.72E+03
Eu-152	---	---	1.14E-01	---	5.09E-04	3.66E+03	---	3.66E+03
Eu-154	---	---	7.90E-01	1.40E+00	3.50E-02	1.77E+03	---	1.78E+03
Cm-244	---	---	9.63E-02	---	---	9.44E+02	---	1.10E+03
Co-60	2.30E+00	3.36E+02	1.30E+01	2.75E-01	4.17E+00	6.14E+02	---	9.70E+02
Pu-239	4.00E-01	3.35E+02	2.98E+01	3.30E-03	9.28E+01	9.85E+01	---	5.59E+02
Am-241	5.85E-02	1.93E+02	4.68E+01	5.07E-02	---	2.42E+02	5.39E-01	4.83E+02
Eu-155	---	---	3.35E-01	1.81E-01	1.77E+00	3.51E+02	---	3.53E+02
Pu-240	---	1.67E+02	2.48E+01	3.10E-03	---	1.07E+00	---	1.93E+02
Th-231	4.73E-10	1.46E-01	6.42E-03	---	8.78E-03	1.86E+02	---	1.86E+02
U-235	4.73E-10	1.46E-01	5.38E-03	---	8.78E-03	1.86E+02	---	1.86E+02
Pu-238	---	4.67E+01	6.09E+01	9.27E-01	3.90E+00	2.81E+01	1.98E+01	1.69E+02
Cm-243	---	---	1.45E-02	---	---	1.48E+02	---	1.48E+02
Cs-134	---	---	5.38E+01	4.73E+00	2.42E-02	9.57E+00	---	6.81E+01
U-233	---	4.15E-01	3.91E-01	---	---	5.73E+01	---	5.81E+01
Pm-147	---	---	1.49E+01	4.34E+00	1.13E+01	---	---	3.34E+01
Rh-106	---	---	6.65E-02	4.98E-01	3.38E-01	3.21E+01	---	3.30E+01
Ru-106	---	---	6.65E-02	4.98E-01	3.38E-01	3.21E+01	---	3.30E+01
Pr-144	---	---	3.93E+00	1.54E+00	1.58E-02	1.51E+01	---	2.05E+01
Ce-144	---	---	3.98E+00	1.56E+00	1.60E-02	1.20E+01	---	1.75E+01
C-14	---	---	4.00E-02	---	---	6.11E+00	---	6.15E+00
Kr-85	---	---	5.95E+00	---	---	---	---	5.95E+00
Sb-125	---	---	9.81E-01	5.33E-01	2.79E+00	---	---	4.30E+00
Cf-252	---	---	---	---	---	3.86E+00	---	3.86E+00
Ni-63	---	---	3.50E+00	---	---	---	---	3.50E+00
U-238	---	1.03E-02	3.57E-03	---	2.00E-05	3.37E+00	---	3.38E+00
Pa-234m	---	1.03E-02	1.38E-03	---	2.00E-05	3.37E+00	---	3.38E+00
Th-234	---	1.03E-02	1.38E-03	---	2.00E-05	3.37E+00	---	3.38E+00
U-232	---	---	---	---	---	1.76E+00	---	1.76E+00
Po-216	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.69E+00
Bi-212	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
Pb-212	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
Ra-224	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
Rn-220	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
Th-228	---	1.49E-03	2.65E-05	---	---	1.68E+00	---	1.68E+00
U-234	---	1.29E+00	1.51E-01	4.98E-06	1.11E-05	2.02E-03	4.94E-04	1.45E+00
Po-212	---	9.54E-04	1.70E-05	---	---	1.07E+00	---	1.07E+00
Te-125m	---	---	2.39E-01	1.30E-01	6.88E-01	---	---	1.06E+00

[a] Dashed line indicates that information was not available

Table A-26 gives RH-TRU waste volume factors according to site. Here, the Proposed Action radionuclide loading was adjusted down to meet the WIPP regulatory limit of 7,080 cubic meters (250,000 cubic feet). As stated previously, volume factors among the Draft WM PEIS regionalized options within an alternative are the same.

A.4.2 Radionuclide Estimates for the Proposed Action

The following sections discuss the radionuclide estimates used for risk analyses of the Proposed Action.

Table A-25
Volume Factors Used to Estimate Total CH-TRU Radionuclide Inventories at Each Site [a]

Site	Proposed Action	Action Alternatives 1 and 3	Action Alternative 2 and No Action Alternative 1	No Action Alternative 2
Ames Laboratory - Iowa State University (Ames)	N/A	N/A	N/A	N/A
ARCO Medical Products Company (ARCO)	0.000	2.500	2.500	0.000
Argonne National Laboratory- East (ANL-E)	9.587	8.111	8.111	8.111
Argonne National Laboratory- West (ANL-W)	N/A	N/A	N/A	N/A
Bettis Atomic Power Laboratory (Bettis)	N/A	N/A	N/A	N/A
Energy Technology Engineering Center (ETEC)	1.182	1.000	1.000	1.000
Hanford Site (Hanford)	5.524	9.762	9.782	4.673
Idaho National Engineering Laboratory (INEL)	1.182	3.009	3.026	1.000
Lawrence Berkeley Laboratory (LBL)	0.000	3.262	3.262	0.000
Lawrence Livermore National Laboratory (LLNL)	6.130	5.186	5.186	5.186
Los Alamos National Laboratory (LANL)	2.249	3.158	3.158	1.903
Mound Plant (Mound)	1.182	1.000	1.064	1.000
Nevada Test Site (NTS)	1.205	1.020	1.020	1.020
Oak Ridge National Laboratory (ORNL)	1.493	1.313	1.313	1.263
Paducah Gaseous Diffusion Plant (PGDP)[b]	1.604	1.357	1.357	1.357
Pantex Plant (Pantex)	1.182	1.000	1.000	1.000
Rocky Flats Environmental Technology Site (RFETS)[c]	11.185	9.462	9.462	9.462
Sandia National Laboratories (SNL)	N/A	N/A	N/A	N/A
Savannah River Site (SRS)[d]	2.362	2.528	2.528	1.998
Teledyne Brown Engineering (TBE)	N/A	NA	N/A	NA
U.S. Army Materiel Command (USAMC)	1.182	1.000	1.000	1.000
University of Missouri Research Reactor (U of MO)	7.599	6.429	6.429	6.429
West Valley Demonstration Project (WVDP)	N/A	N/A	N/A	N/A

[a] Volume factors are used in equation A-8
[b] PDGP is assumed to be the projected BIR-2 volume
[c] RFETS residue data are not included in the volume factors
[d] IDB volume of 9,200 cubic meters used for SRS

Table A-26
Volume Factors Used to Estimate Total RH-TRU Radionuclide Inventories at Each Site [a]

Site	Proposed Action	Action Alternative 1	Action Alternative 2	Action Alternative 3	No Action Alternative 1	No Action Alternative 2
ETEC	1.179	1.179	1.179	1.179	1.179	1.179
Hanford	9.779	150.708	150.708	150.708	145.610	150.708
INEL	1.000	3.009	3.009	3.009	1.000	3.009
Knolls [b]	0.000	6.712	6.712	6.712	0.000	6.712
LANL	2.421	3.677	3.677	3.677	2.421	3.677
ORNL	0.084	1.292	1.292	1.292	1.246	1.292
WVDP	0.000	5.606	5.606	5.606	0.000	5.606

[a] Volume factors are used in equation A-8
[b] IDB volume for Knolls assumed to be 20 percent of the BIR-2 projected volume

A.4.2.1 CH-TRU Waste

Assuming that the volume of CH-TRU waste disposed of at WIPP would be the maximum allowed under the LWA, the Proposed Action CH-TRU waste radionuclide inventory, summed over all radionuclides, would be approximately 5.25 x 10^6 Ci. The Proposed Action CH-TRU waste radionuclide inventory for each treatment site is given in Table A-27. Only radionuclides with total inventories of 1 Ci or more were included in the analyses.

When radionuclide inventory data were not available for a site, the average radionuclide concentration taken from the other sites were assigned. RFETS residue data were not included in the determination of the average radionuclide concentrations due to the unique characteristics of the residues.

Pu-238 is a major contributor to the total radionuclide activity, accounting for 32 percent of the total activity. Approximately half of the Pu-238 is generated at SRS. These SEIS-II data are higher than that reported in SEIS-I, where Pu-238 represented only about 1 percent of the total CH-TRU waste activity.

A.4.2.2 RH-TRU Waste

The RH-TRU waste radionuclide inventory according to treatment site under the Proposed Action is given in Table A-28. Radionuclides with total inventories of less than 1 Ci were not included in the analysis. The total radionuclide loading for the Proposed Action is 4.3 x 10^5 Ci, which is less than the LWA imposed limit of 5.1 x 10^6 Ci.

A.4.3 Radionuclide Estimates for Action Alternative 1

The following sections describe the radionuclide estimates for the risk analyses conducted for Action Alternative 1.

A.4.3.1 CH-TRU Waste

CH-TRU waste radionuclide inventory according to treatment site for Action Alternative 1 is given in Table A-29. Radionuclides with total inventories of less than 1 Ci were not included in the analysis.

When radionuclide inventory data were not available for a site, the average radionuclide concentration taken from the other sites were assigned. As previously mentioned, RFETS residue data were excluded when computing the average concentration of CH-TRU waste. The total radionuclide loading for CH-TRU waste under Action Alternative 1 is 6.8 x 10^6 Ci.

A.4.3.2 RH-TRU Waste

The RH-TRU waste radionuclide inventory according to treatment site under Action Alternative 1 is given in Table A-30. Radionuclides with total inventories of less than 1 Ci were not included in the analysis. The total radionuclide loading for RH-TRU waste under Action Alternative 1 is 5.1 x 10^6 Ci.

Table A-27
Radionuclide Inventories (Ci) for CH-TRU Waste by Treatment Site for the Proposed Action [a]

Isotope	Hanford	INEL	LANL	LLNL	MOUND	NTS	ORNL	RFETS	SRS	ANL-E	Total
Pu-238	4.45E+05	8.27E+04	2.58E+05	4.69E+02	6.46E+02	3.79E+04	7.29E+03	1.20E+04	8.57E+05	4.36E+01	1.70E+06
Pu-241	2.09E+05	1.83E+05	3.75E+03	1.00E+04	0.00E+00	2.96E+02	7.35E+04	1.60E+06	1.74E+05	1.13E+03	2.25E+06
Pu-239	1.45E+05	4.99E+04	1.78E+05	1.01E+03	8.16E+00	3.33E+03	4.55E+03	2.85E+05	1.45E+04	6.79E+02	6.82E+05
Am-241	2.62E+04	1.08E+05	2.63E+04	8.81E+02	0.00E+00	3.43E+02	2.73E+03	2.31E+05	3.11E+03	1.22E+02	3.99E+05
Pu-240	3.40E+04	1.20E+04	2.34E+02	3.95E+02	0.00E+00	3.28E+01	1.50E+03	1.21E+05	3.58E+03	1.95E+02	1.72E+05
Cs-137	3.78E+03	1.16E+02	1.09E+02	1.02E-05	0.00E+00	4.34E-01	3.91E+00	0.00E+00	1.16E+01	0.00E+00	7.54E+03
Ba-137m	3.58E+03	1.10E+02	1.03E+02	9.64E-06	0.00E+00	4.11E-01	3.70E+00	0.00E+00	1.10E+01	0.00E+00	7.14E+03
Cm-244	3.78E+02	6.28E+02	3.53E+02	4.01E+02	0.00E+00	2.75E+02	1.61E+03	0.00E+00	1.81E+03	0.00E+00	5.46E+03
Y-90	3.83E+03	3.41E+01	1.00E+02	0.00E+00	0.00E+00	6.10E-01	2.24E+03	0.00E+00	1.08E+01	0.00E+00	6.22E+03
Sr-90	3.83E+03	3.41E+01	1.00E+02	0.00E+00	0.00E+00	6.10E-01	2.24E+03	0.00E+00	1.08E+01	0.00E+00	6.21E+03
U-233	4.43E+02	1.08E+03	1.01E+02	3.65E-08	0.00E+00	2.18E+00	2.71E+02	1.45E+02	5.82E+00	6.21E-01	2.05E+03
Pu-242	2.10E+00	8.08E+00	1.09E+03	1.24E-01	0.00E+00	1.05E-01	1.52E+00	1.08E-03	5.82E-01	2.07E-01	1.10E+03
U-234	2.97E+02	8.83E+00	1.37E+01	2.02E-02	3.21E-02	1.51E-02	2.40E+01	5.38E-02	3.97E+01	0.00E+00	3.84E+02
Pa-233	1.50E+00	1.94E+00	8.80E-02	2.89E-03	0.00E+00	6.97E-03	1.34E+00	1.91E-01	1.33E+01	0.00E+00	1.84E+01
Np-237	1.50E+00	1.94E+00	8.80E-02	2.89E-03	0.00E+00	6.97E-03	1.33E+00	1.91E-01	1.33E+01	0.00E+00	1.84E+01
Co-60	0.00E+00	7.47E+01	1.49E-02	0.00E+00	0.00E+00	0.00E+00	1.49E-01	0.00E+00	5.51E-01	0.00E+00	7.54E+01
Eu-155	5.84E-03	1.22E+00	5.55E-01	0.00E+00	0.00E+00	4.58E-03	1.27E-01	0.00E+00	8.19E+01	0.00E+00	8.38E+01
Cf-252	1.95E+02	5.14E-01	8.50E-03	0.00E+00	0.00E+00	2.05E-02	3.27E-01	0.00E+00	5.61E-01	0.00E+00	1.96E+02
Pb-212	2.87E-01	3.14E+01	2.02E-02	0.00E+00	0.00E+00	1.98E-02	4.92E-01	0.00E+00	1.43E-02	0.00E+00	3.22E+01
Ra-224	2.87E-01	3.14E+01	9.29E-03	0.00E+00	0.00E+00	2.07E-02	4.92E-01	0.00E+00	1.43E-02	0.00E+00	3.22E+01
Bi-212	2.87E-01	3.14E+01	9.29E-03	0.00E+00	0.00E+00	1.98E-02	4.92E-01	0.00E+00	1.43E-02	0.00E+00	3.22E+01
Po-216	2.87E-01	3.14E+01	9.29E-03	0.00E+00	0.00E+00	1.98E-02	4.92E-01	0.00E+00	1.43E-02	0.00E+00	3.22E+01
Rn-220	2.87E-01	3.14E+01	9.29E-03	0.00E+00	0.00E+00	1.98E-02	4.92E-01	0.00E+00	1.43E-02	0.00E+00	3.22E+01
Th-228	2.87E-01	3.14E+01	9.29E-03	0.00E+00	0.00E+00	1.98E-02	4.92E-01	0.00E+00	1.43E-02	0.00E+00	3.22E+01
U-232	0.00E+00	3.03E+01	9.87E-03	0.00E+00	0.00E+00	1.98E-02	5.00E-01	0.00E+00	1.39E-01	0.00E+00	3.10E+01
Np-239	4.99E-01	7.53E-01	8.61E+00	1.50E-01	0.00E+00	1.47E+00	2.26E+01	0.00E+00	1.17E+00	1.97E+00	3.72E+01
Am-243	4.99E-01	7.07E-01	8.61E+00	1.50E-01	0.00E+00	1.47E+00	1.76E+01	0.00E+00	1.17E+00	1.97E+00	3.22E+01
Tc-99	5.26E-05	2.57E-01	2.72E-02	0.00E+00	0.00E+00	7.22E-05	2.70E+01	0.00E+00	6.97E-06	0.00E+00	2.73E+01
Po-212	1.84E-01	2.01E+01	5.95E-03	0.00E+00	0.00E+00	1.27E-02	3.15E-01	0.00E+00	9.14E-03	0.00E+00	2.06E+01
Cm-245	9.29E+01	2.40E-01	3.99E-03	0.00E+00	0.00E+00	1.14E-05	3.99E-02	0.00E+00	0.00E+00	0.00E+00	9.31E+01
Tl-208	1.03E-01	1.13E+01	3.34E-03	0.00E+00	0.00E+00	7.10E-03	1.77E-01	0.00E+00	5.12E-03	0.00E+00	1.16E+01
U-237	5.13E+00	4.46E+00	9.16E-02	2.45E-01	0.00E+00	7.26E-03	1.80E+00	1.43E+01	2.36E+00	0.00E+00	2.84E+01
Ra-226	1.74E-04	1.68E-01	2.04E+00	2.45E-07	5.80E-09	3.01E-01	9.91E+00	0.00E+00	1.13E-05	0.00E+00	1.24E+01
Po-218	1.74E-04	1.67E-01	2.04E+00	0.00E+00	5.80E-09	3.01E-01	9.84E+00	0.00E+00	1.13E-05	0.00E+00	1.23E+01
Rn-222	1.74E-04	1.67E-01	2.04E+00	0.00E+00	5.80E-09	3.01E-01	9.84E+00	0.00E+00	1.13E-05	0.00E+00	1.23E+01
Bi-214	1.74E-04	1.67E-01	2.04E+00	0.00E+00	5.80E-09	3.01E-01	9.84E+00	0.00E+00	1.13E-05	0.00E+00	1.23E+01
Pb-214	1.74E-04	1.67E-01	2.04E+00	0.00E+00	5.80E-09	3.01E-01	9.84E+00	0.00E+00	1.13E-05	0.00E+00	1.23E+01
Po-214	1.74E-04	1.67E-01	2.04E+00	0.00E+00	5.80E-09	3.01E-01	9.84E+00	0.00E+00	1.13E-05	0.00E+00	1.23E+01
Ag-109m	0.00E+00	9.36E-02	1.47E+01	0.00E+00	0.00E+00	0.00E+00	1.56E-02	0.00E+00	0.00E+00	0.00E+00	1.49E+01
Cd-109	0.00E+00	9.36E-02	1.47E+01	0.00E+00	0.00E+00	0.00E+00	1.55E-02	0.00E+00	0.00E+00	0.00E+00	1.48E+01
Pa-234m	3.24E+01	2.24E-01	5.50E-02	1.86E-01	0.00E+00	4.17E-04	7.88E-02	0.00E+00	8.84E-03	0.00E+00	3.30E+01
Th-234	3.24E+01	2.24E-01	5.46E-02	1.86E-01	0.00E+00	3.84E-04	7.88E-02	0.00E+00	8.84E-03	0.00E+00	3.30E+01
U-238	3.24E+01	2.24E-01	5.46E-02	1.86E-01	0.00E+00	1.98E-04	7.88E-02	0.00E+00	8.84E-03	0.00E+00	3.30E+01
Pm-147	2.64E-01	3.17E+00	4.51E+00	0.00E+00	0.00E+00	1.26E-01	4.07E-02	0.00E+00	1.91E-05	0.00E+00	8.11E+00
U-235	9.46E+00	1.06E-01	1.19E+00	3.63E-03	1.37E-07	1.41E-02	2.57E-02	5.35E-04	9.05E-03	0.00E+00	1.08E+01
Th-231	9.46E+00	1.06E-01	1.19E+00	1.08E-02	1.37E-07	7.41E-05	2.75E-02	5.35E-04	9.05E-03	0.00E+00	1.08E+01
Ac-225	7.23E-01	1.82E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.18E-01	0.00E+00	2.03E-05	0.00E+00	3.05E+00
Th-229	7.23E-01	1.82E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.18E-01	0.00E+00	2.03E-05	0.00E+00	3.05E+00
Ra-225	7.23E-01	1.82E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.18E-01	0.00E+00	2.03E-05	0.00E+00	3.05E+00
At-217	7.23E-01	1.82E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.18E-01	0.00E+00	2.03E-05	0.00E+00	3.05E+00
Bi-213	7.23E-01	1.82E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.18E-01	0.00E+00	2.03E-05	0.00E+00	3.05E+00
Fr-221	7.23E-01	1.82E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.18E-01	0.00E+00	2.03E-05	0.00E+00	3.05E+00
Pb-209	7.23E-01	1.82E+00	1.82E-01	0.00E+00	0.00E+00	2.90E-03	3.18E-01	0.00E+00	2.03E-05	0.00E+00	3.05E+00
Po-213	7.07E-01	1.78E+00	1.78E-01	0.00E+00	0.00E+00	2.84E-03	3.11E-01	0.00E+00	1.99E-05	0.00E+00	2.98E+00
C-14	8.85E+00	2.22E-01	4.20E-04	0.00E+00	0.00E+00	3.01E-04	4.19E-03	0.00E+00	0.00E+00	0.00E+00	9.08E+00
Bi-210	2.93E-05	5.54E-02	6.31E-01	0.00E+00	6.75E-10	8.06E-02	1.92E+00	0.00E+00	1.72E-06	0.00E+00	2.68E+00
Po-210	2.93E-05	5.54E-02	6.31E-01	0.00E+00	6.75E-10	8.06E-02	1.92E+00	0.00E+00	1.72E-06	0.00E+00	2.68E+00
Pb-210	2.93E-05	5.54E-02	6.31E-01	0.00E+00	6.75E-10	8.06E-02	1.92E+00	0.00E+00	1.72E-06	0.00E+00	2.68E+00
Eu-152	4.06E-06	2.09E-01	1.23E-03	8.15E-06	0.00E+00	1.28E+00	3.84E-03	0.00E+00	0.00E+00	0.00E+00	1.49E+00
Cm-243	8.42E-02	1.60E-02	2.49E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-03	0.00E+00	0.00E+00	0.00E+00	2.59E+00
Eu-154	3.44E-04	7.76E-01	5.54E-02	3.22E-06	0.00E+00	5.16E-01	2.60E-03	0.00E+00	4.41E-04	0.00E+00	1.35E+00

[a] This table lists only radionuclides with activities of 1 curie or more. Information about radionuclides with lower activities is contained in Table 4-6 of the draft Compliance Certification Application.

Table A-28
Radionuclide Inventories (Ci) for RH-TRU Waste by Treatment Site for the Proposed Action [a]

Isotope	Hanford	INEL	LANL	ORNL	Total
Y-90	6.32E+04	2.45E+04	3.01E+02	1.07E+04	9.88E+04
Sr-90	6.32E+04	2.45E+04	3.00E+02	1.07E+04	9.87E+04
Cs-137	6.83E+04	1.18E+04	3.27E+02	4.19E+03	8.46E+04
Ba-137m	6.46E+04	1.12E+04	3.10E+02	3.96E+03	8.00E+04
Pu-241	4.56E+04	2.52E+03	0.00E+00	8.40E+02	4.90E+04
Eu-152	0.00E+00	1.92E+03	1.23E-03	9.59E+02	2.88E+03
Eu-154	0.00E+00	9.31E+02	8.47E-02	4.64E+02	1.40E+03
Cm-244	0.00E+00	5.79E+02	0.00E+00	2.76E+02	8.55E+02
Co-60	3.29E+03	5.22E+02	1.01E+01	2.24E+02	4.05E+03
Pu-239	3.28E+03	3.23E+02	2.25E+02	1.08E+02	3.93E+03
Am-241	1.89E+03	3.00E+02	0.00E+00	1.06E+02	2.30E+03
Eu-155	0.00E+00	1.85E+02	4.29E+00	9.22E+01	2.82E+02
Pu-240	1.63E+03	1.26E+02	0.00E+00	3.44E+01	1.79E+03
Th-231	1.43E+00	9.74E+01	2.13E-02	4.86E+01	1.48E+02
U-235	1.43E+00	9.74E+01	2.13E-02	4.86E+01	1.48E+02
Pu-238	4.57E+02	1.50E+02	9.44E+00	3.25E+01	6.48E+02
Cm-243	0.00E+00	7.77E+01	0.00E+00	3.88E+01	1.17E+02
Cs-134	0.00E+00	8.95E+01	5.85E-02	1.29E+01	1.02E+02
U-233	4.06E+00	3.08E+01	0.00E+00	1.51E+01	5.00E+01
Pm-147	0.00E+00	3.24E+01	2.73E+01	5.95E+00	6.57E+01
Rh-106	0.00E+00	1.74E+01	8.18E-01	8.56E+00	2.67E+01
Ru-106	0.00E+00	1.74E+01	8.18E-01	8.56E+00	2.67E+01
Pr-144	0.00E+00	1.47E+01	3.84E-02	4.92E+00	1.97E+01
Ce-144	0.00E+00	1.32E+01	3.88E-02	4.13E+00	1.73E+01
C-14	0.00E+00	3.26E+00	0.00E+00	1.61E+00	4.87E+00
Kr-85	0.00E+00	9.07E+00	0.00E+00	1.06E+00	1.01E+01
Sb-125	0.00E+00	3.24E+00	6.75E+00	7.66E-01	1.08E+01
Cf-252	0.00E+00	2.02E+00	0.00E+00	1.01E+00	3.03E+00
Ni-63	0.00E+00	5.34E+00	0.00E+00	6.23E-01	5.96E+00
U-238	1.00E-01	1.78E+00	4.84E-05	8.84E-01	2.76E+00
Pa-234m	1.00E-01	1.77E+00	4.84E-05	8.84E-01	2.76E+00
Th-234	1.00E-01	1.77E+00	4.84E-05	8.84E-01	2.76E+00
U-232	0.00E+00	9.25E-01	0.00E+00	4.62E-01	1.39E+00
Po-216	1.46E-02	8.84E-01	0.00E+00	4.40E-01	1.34E+00
Bi-212	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
Pb-212	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
Ra-224	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
Rn-220	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
Th-228	1.46E-02	8.79E-01	0.00E+00	4.39E-01	1.33E+00
U-234	1.26E+01	9.08E-01	2.69E-05	2.57E-01	1.38E+01
Po-212	9.33E-03	5.63E-01	0.00E+00	2.81E-01	8.53E-01
Te-125m	0.00E+00	7.94E-01	1.67E+00	1.88E-01	2.65E+00

[a] This table lists only radionuclides with activities of 1 curie or more. Information about radionuclides with lower activities is contained in Table 4-6 of the draft Compliance Certification Application.

Table A-29
Radionuclide Inventories (Ci) for CH-TRU Waste by Treatment Site for Action Alternative 1

Isotope	Hanford	INEL	LANL	LLNL	MOUND	NTS	ORNL	RFETS	SRS	ANL-E	Total
Pu-238	7.87E+05	1.92E+05	3.62E+05	3.97E+02	5.46E+02	3.21E+04	9.89E+03	1.14E+04	1.02E+06	3.69E+01	2.41E+06
Pu-241	3.69E+05	4.57E+05	5.23E+03	8.46E+03	0.00E+00	2.50E+02	6.58E+04	1.51E+06	2.06E+05	9.52E+02	2.62E+06
Pu-239	2.57E+05	1.23E+05	2.50E+05	8.52E+02	6.90E+00	2.82E+03	4.51E+03	2.68E+05	1.72E+04	5.75E+02	9.24E+05
Am-241	4.63E+04	2.73E+05	3.69E+04	7.46E+02	0.00E+00	2.90E+02	2.77E+03	2.12E+05	3.69E+03	1.03E+02	5.76E+05
Pu-240	6.01E+04	3.00E+04	3.27E+02	3.34E+02	0.00E+00	2.78E+01	1.40E+03	1.08E+05	4.25E+03	1.65E+02	2.05E+05
Cs-137	6.68E+03	2.26E+02	1.53E+02	8.62E-06	0.00E+00	3.67E-01	5.85E+00	0.00E+00	1.38E+01	0.00E+00	1.02E+04
Ba-137m	6.32E+03	2.14E+02	1.44E+02	8.16E-06	0.00E+00	3.47E-01	5.54E+00	0.00E+00	1.31E+01	0.00E+00	9.63E+03
Cm-244	6.68E+02	1.53E+03	4.95E+02	3.39E+02	0.00E+00	2.33E+02	1.43E+03	0.00E+00	2.15E+03	0.00E+00	6.84E+03
Y-90	6.77E+03	3.76E+01	1.41E+02	0.00E+00	0.00E+00	5.16E-01	1.98E+03	0.00E+00	1.29E+01	0.00E+00	8.94E+03
Sr-90	6.77E+03	3.76E+01	1.41E+02	0.00E+00	0.00E+00	5.16E-01	1.98E+03	0.00E+00	1.29E+01	0.00E+00	8.93E+03
U-233	7.82E+02	2.72E+03	1.41E+02	3.08E-08	0.00E+00	1.85E+00	2.42E+02	1.23E+02	6.91E+00	5.26E-01	4.02E+03
Pu-242	3.75E+00	9.80E+00	1.53E+03	1.05E-01	0.00E+00	8.88E-02	2.80E+00	9.11E-04	6.91E-01	1.75E-01	1.55E+03
U-234	5.26E+02	2.01E+01	1.92E+01	1.70E-02	2.71E-02	1.28E-02	2.14E+01	4.55E-02	4.71E+01	0.00E+00	6.33E+02
Pa-233	2.66E+00	3.50E+00	1.19E-01	2.44E-03	0.00E+00	5.89E-03	1.37E+00	1.61E-01	1.58E+01	0.00E+00	2.36E+01
Np-237	2.66E+00	3.50E+00	1.19E-01	2.44E-03	0.00E+00	5.89E-03	1.36E+00	1.61E-01	1.58E+01	0.00E+00	2.36E+01
Co-60	0.00E+00	1.89E+02	1.61E-02	0.00E+00	0.00E+00	0.00E+00	3.20E-01	0.00E+00	6.55E-01	0.00E+00	1.90E+02
Eu-155	1.03E-02	1.92E+00	7.75E-01	0.00E+00	0.00E+00	3.87E-03	2.73E-01	0.00E+00	9.72E+01	0.00E+00	1.00E+02
Cf-252	3.45E+02	5.18E-01	9.17E-03	0.00E+00	0.00E+00	1.74E-02	3.96E-01	0.00E+00	6.66E-01	0.00E+00	3.46E+02
Pb-212	5.07E-01	7.93E+01	2.63E-02	0.00E+00	0.00E+00	1.67E-02	5.13E-01	0.00E+00	1.69E-02	0.00E+00	8.04E+01
Ra-224	5.07E-01	7.93E+01	1.10E-02	0.00E+00	0.00E+00	1.75E-02	5.13E-01	0.00E+00	1.69E-02	0.00E+00	8.04E+01
Bi-212	5.07E-01	7.93E+01	1.10E-02	0.00E+00	0.00E+00	1.67E-02	5.13E-01	0.00E+00	1.69E-02	0.00E+00	8.04E+01
Po-216	5.07E-01	7.93E+01	1.10E-02	0.00E+00	0.00E+00	1.67E-02	5.13E-01	0.00E+00	1.69E-02	0.00E+00	8.04E+01
Rn-220	5.07E-01	7.93E+01	1.10E-02	0.00E+00	0.00E+00	1.67E-02	5.13E-01	0.00E+00	1.69E-02	0.00E+00	8.04E+01
Th-228	5.07E-01	7.93E+01	1.10E-02	0.00E+00	0.00E+00	1.67E-02	5.13E-01	0.00E+00	1.69E-02	0.00E+00	8.04E+01
U-232	0.00E+00	7.66E+01	1.19E-02	0.00E+00	0.00E+00	1.68E-02	5.18E-01	0.00E+00	1.65E-01	0.00E+00	7.73E+01
Np-239	1.01E+00	1.45E+00	1.21E+01	1.27E-01	0.00E+00	1.25E+00	1.99E+01	0.00E+00	1.39E+00	1.67E+00	3.89E+01
Am-243	1.01E+00	1.40E+00	1.21E+01	1.27E-01	0.00E+00	1.25E+00	1.56E+01	0.00E+00	1.39E+00	1.67E+00	3.45E+01
Tc-99	9.30E-05	2.61E-01	3.69E-02	0.00E+00	0.00E+00	6.11E-05	2.38E+01	0.00E+00	8.28E-06	0.00E+00	2.41E+01
Po-212	3.25E-01	5.08E+01	7.04E-03	0.00E+00	0.00E+00	1.07E-02	3.29E-01	0.00E+00	1.09E-02	0.00E+00	5.15E+01
Cm-245	1.64E+02	2.40E-01	4.31E-03	0.00E+00	0.00E+00	9.62E-06	8.57E-02	0.00E+00	0.00E+00	0.00E+00	1.64E+02
Tl-208	1.82E-01	2.85E+01	3.95E-03	0.00E+00	0.00E+00	6.01E-03	1.84E-01	0.00E+00	6.09E-03	0.00E+00	2.89E+01
U-237	9.06E+00	1.12E+01	1.28E-01	2.07E-01	0.00E+00	6.14E-03	1.61E+00	1.21E+01	2.80E+00	0.00E+00	3.71E+01
Ra-226	1.10E-01	2.55E-01	2.86E+00	2.07E-07	4.91E-09	2.54E-01	8.74E+00	0.00E+00	1.34E-05	0.00E+00	1.22E+01
Po-218	1.10E-01	2.55E-01	2.86E+00	0.00E+00	4.91E-09	2.54E-01	8.68E+00	0.00E+00	1.34E-05	0.00E+00	1.22E+01
Rn-222	1.10E-01	2.55E-01	2.86E+00	0.00E+00	4.91E-09	2.54E-01	8.68E+00	0.00E+00	1.34E-05	0.00E+00	1.22E+01
Bi-214	1.10E-01	2.55E-01	2.86E+00	0.00E+00	4.91E-09	2.54E-01	8.68E+00	0.00E+00	1.34E-05	0.00E+00	1.22E+01
Pb-214	1.10E-01	2.55E-01	2.86E+00	0.00E+00	4.91E-09	2.54E-01	8.68E+00	0.00E+00	1.34E-05	0.00E+00	1.22E+01
Po-214	1.10E-01	2.55E-01	2.86E+00	0.00E+00	4.91E-09	2.54E-01	8.67E+00	0.00E+00	1.34E-05	0.00E+00	1.22E+01
Ag-109m	0.00E+00	9.36E-02	2.07E+01	0.00E+00	0.00E+00	0.00E+00	3.35E-02	0.00E+00	0.00E+00	0.00E+00	2.08E+01
Cd-109	0.00E+00	9.36E-02	2.07E+01	0.00E+00	0.00E+00	0.00E+00	3.34E-02	0.00E+00	0.00E+00	0.00E+00	2.08E+01
Pa-234m	5.73E+01	4.35E-01	7.67E-02	1.57E-01	0.00E+00	3.53E-04	8.77E-02	0.00E+00	1.05E-02	0.00E+00	5.81E+01
Th-234	5.73E+01	4.35E-01	7.62E-02	1.57E-01	0.00E+00	3.24E-04	8.77E-02	0.00E+00	1.05E-02	0.00E+00	5.81E+01
U-238	5.73E+01	4.35E-01	7.62E-02	1.57E-01	0.00E+00	1.67E-04	8.77E-02	0.00E+00	1.05E-02	0.00E+00	5.81E+01
Pm-147	4.67E-01	7.96E+00	6.33E+00	0.00E+00	0.00E+00	1.07E-01	5.03E-02	0.00E+00	2.27E-05	0.00E+00	1.49E+01
U-235	1.67E+01	2.19E-01	1.66E+00	3.08E-03	1.16E-07	1.19E-02	2.96E-02	4.52E-04	1.08E-02	0.00E+00	1.87E+01
Th-231	1.67E+01	2.19E-01	1.66E+00	9.15E-03	1.16E-07	6.27E-05	3.12E-02	4.52E-04	1.08E-02	0.00E+00	1.87E+01
Ac-225	1.28E+00	4.60E+00	2.55E-01	0.00E+00	0.00E+00	2.46E-03	2.86E-01	0.00E+00	2.41E-05	0.00E+00	6.42E+00
Th-229	1.28E+00	4.60E+00	2.55E-01	0.00E+00	0.00E+00	2.46E-03	2.85E-01	0.00E+00	2.41E-05	0.00E+00	6.42E+00
Ra-225	1.28E+00	4.60E+00	2.55E-01	0.00E+00	0.00E+00	2.46E-03	2.85E-01	0.00E+00	2.41E-05	0.00E+00	6.42E+00
At-217	1.28E+00	4.60E+00	2.55E-01	0.00E+00	0.00E+00	2.46E-03	2.85E-01	0.00E+00	2.41E-05	0.00E+00	6.42E+00
Bi-213	1.28E+00	4.60E+00	2.55E-01	0.00E+00	0.00E+00	2.46E-03	2.85E-01	0.00E+00	2.41E-05	0.00E+00	6.42E+00
Fr-221	1.28E+00	4.60E+00	2.55E-01	0.00E+00	0.00E+00	2.46E-03	2.85E-01	0.00E+00	2.41E-05	0.00E+00	6.42E+00
Pb-209	1.28E+00	4.60E+00	2.55E-01	0.00E+00	0.00E+00	2.46E-03	2.85E-01	0.00E+00	2.41E-05	0.00E+00	6.42E+00
Po-213	1.25E+00	4.50E+00	2.50E-01	0.00E+00	0.00E+00	2.40E-03	2.79E-01	0.00E+00	2.36E-05	0.00E+00	6.28E+00
C-14	1.56E+01	5.26E-01	4.53E-04	0.00E+00	0.00E+00	2.55E-04	9.01E-03	0.00E+00	0.00E+00	0.00E+00	1.62E+01
Bi-210	2.93E-02	1.05E-01	8.86E-01	0.00E+00	5.71E-10	6.82E-02	1.69E+00	0.00E+00	2.04E-06	0.00E+00	2.78E+00
Po-210	2.93E-02	1.05E-01	8.86E-01	0.00E+00	5.71E-10	6.82E-02	1.69E+00	0.00E+00	2.04E-06	0.00E+00	2.78E+00
Pb-210	2.93E-02	1.05E-01	8.86E-01	0.00E+00	5.71E-10	6.82E-02	1.69E+00	0.00E+00	2.04E-06	0.00E+00	2.78E+00
Eu-152	7.17E-06	5.06E-01	1.63E-03	6.90E-06	0.00E+00	1.08E+00	7.06E-03	0.00E+00	0.00E+00	0.00E+00	1.59E+00
Cm-243	1.49E-01	1.60E-02	3.50E+00	0.00E+00	0.00E+00	0.00E+00	5.73E-03	0.00E+00	0.00E+00	0.00E+00	3.67E+00
Eu-154	6.08E-04	1.95E+00	7.77E-02	2.72E-06	0.00E+00	4.37E-01	5.60E-03	0.00E+00	5.23E-04	0.00E+00	2.47E+00

Table A-30
Radionuclide Inventories (Ci) for RH-TRU Waste by Treatment Site for Action Alternative 1

Isotope	Hanford	INEL	LANL	ORNL	Total
Y-90	9.74E+05	2.80E+04	4.56E+02	5.38E+04	1.06E+06
Sr-90	9.74E+05	2.80E+04	4.56E+02	5.38E+04	1.06E+06
Cs-137	1.05E+06	1.56E+04	4.97E+02	1.67E+04	1.09E+06
Ba-137m	9.96E+05	1.48E+04	4.70E+02	1.58E+04	1.03E+06
Pu-241	7.03E+05	2.62E+03	0.00E+00	8.45E+02	7.07E+05
Eu-152	0.00E+00	1.92E+03	1.87E-03	5.39E+03	7.31E+03
Eu-154	0.00E+00	9.33E+02	1.29E-01	2.62E+03	3.55E+03
Cm-244	0.00E+00	5.79E+02	0.00E+00	1.42E+03	2.00E+03
Co-60	5.07E+04	5.48E+02	1.53E+01	9.69E+02	5.22E+04
Pu-239	5.05E+04	3.83E+02	3.41E+02	2.27E+02	5.15E+04
Am-241	2.91E+04	3.94E+02	0.00E+00	4.02E+02	2.99E+04
Eu-155	0.00E+00	1.86E+02	6.52E+00	5.17E+02	7.10E+02
Pu-240	2.51E+04	1.76E+02	0.00E+00	3.57E+01	2.53E+04
Th-231	2.20E+01	9.75E+01	3.23E-02	2.73E+02	3.93E+02
U-235	2.20E+01	9.75E+01	3.23E-02	2.73E+02	3.93E+02
Pu-238	7.04E+03	2.72E+02	1.43E+01	1.84E+02	7.51E+03
Cm-243	0.00E+00	7.77E+01	0.00E+00	2.18E+02	2.96E+02
Cs-134	0.00E+00	1.98E+02	8.89E-02	5.62E+01	2.54E+02
U-233	6.25E+01	3.16E+01	0.00E+00	8.44E+01	1.79E+02
Pm-147	0.00E+00	6.24E+01	4.15E+01	3.51E+01	1.39E+02
Rh-106	0.00E+00	1.75E+01	1.24E+00	5.07E+01	6.94E+01
Ru-106	0.00E+00	1.75E+01	1.24E+00	5.07E+01	6.94E+01
Pr-144	0.00E+00	2.26E+01	5.83E-02	3.34E+01	5.61E+01
Ce-144	0.00E+00	2.12E+01	5.90E-02	2.91E+01	5.03E+01
C-14	0.00E+00	3.34E+00	0.00E+00	8.99E+00	1.23E+01
Kr-85	0.00E+00	2.10E+01	0.00E+00	1.06E+00	2.21E+01
Sb-125	0.00E+00	5.21E+00	1.03E+01	4.34E+00	1.98E+01
Cf-252	0.00E+00	2.02E+00	0.00E+00	5.67E+00	7.69E+00
Ni-63	0.00E+00	1.24E+01	0.00E+00	6.23E-01	1.30E+01
U-238	1.55E+00	1.78E+00	7.36E-05	4.96E+00	8.29E+00
Pa-234m	1.55E+00	1.78E+00	7.36E-05	4.96E+00	8.28E+00
Th-234	1.55E+00	1.78E+00	7.36E-05	4.96E+00	8.28E+00
U-232	0.00E+00	9.25E-01	0.00E+00	2.59E+00	3.52E+00
Po-216	2.24E-01	8.84E-01	0.00E+00	2.47E+00	3.57E+00
Bi-212	2.24E-01	8.79E-01	0.00E+00	2.46E+00	3.57E+00
Pb-212	2.24E-01	8.79E-01	0.00E+00	2.46E+00	3.57E+00
Ra-224	2.24E-01	8.79E-01	0.00E+00	2.46E+00	3.57E+00
Rn-220	2.24E-01	8.79E-01	0.00E+00	2.46E+00	3.57E+00
Th-228	2.24E-01	8.79E-01	0.00E+00	2.46E+00	3.57E+00
U-234	1.95E+02	1.21E+00	4.08E-05	2.63E-01	1.96E+02
Po-212	1.44E-01	5.63E-01	0.00E+00	1.58E+00	2.29E+00
Te-125m	0.00E+00	1.27E+00	2.53E+00	1.06E+00	4.87E+00

A.4.4 Radionuclide Estimates for Action Alternative 2

The following sections present the radionuclide estimates for the risk analyses of Action Alternative 2.

A.4.4.1 CH-TRU Waste

The CH-TRU waste radionuclide inventory according to treatment site under Action Alternative 2A is given in Table A-31. Treatment based on the Action Alternative 2B is given in Table A-32. Under Action Alternative 2C, all waste is treated at WIPP. The radionuclide inventory values for Action Alternative 2C, therefore, may be obtained from the "Total" column of either Table A-31 or Table A-32. The total radionuclide loading for CH-TRU waste under both Action Alternatives 2A and 2B is 6.8×10^6 Ci.

A.4.4.2 RH-TRU Waste

RH-TRU waste handling would be the same under Action Alternatives 2A, 2B, and 2C. The radionuclide inventories for all are represented in Table A-33. The total radionuclide loading for RH-TRU waste under Action Alternative 2 would be 5.1×10^6 Ci.

A.4.5 Radionuclide Estimates for Action Alternative 3

The following sections discuss radionuclide estimates for risk analyses for Action Alternative 3.

A.4.5.1 CH-TRU Waste

The CH-TRU waste radionuclide inventory according to treatment site under Action Alternative 3 is given in Table A-34. The total radionuclide loading for CH-TRU waste under this alternative would be 6.8×10^6 Ci.

A.4.5.2 RH-TRU Waste

The RH-TRU waste radionuclide inventory according to treatment site under Action Alternative 3 is given in Table A-35. The total radionuclide loading for RH-TRU waste under this alternative would be 5.1×10^6 Ci.

A.4.6 Radionuclide Estimates for No Action Alternative 1

The CH-TRU waste radionuclide inventory for the treatment sites for No Action Alternative 1 would be the same as those under Action Alternatives 2A and 2B. The radionuclide information is given in Tables A-31 and A-32, respectively.

The RH-TRU waste radionuclide inventory for the treatment sites under this alternative would be the same as those under Action Alternatives 2A and 2B. This radionuclide information is given in Table A-33.

A.4.7 Radionuclide Estimates for No Action Alternative 2

The following sections discuss radionuclide estimates used for the No Action Alternative 2 analyses.

Table A-31
Radionuclide Inventories (Ci) for CH-TRU Waste by Treatment Site for Action Alternative 2A

Isotope	Hanford	INEL	LANL	RFETS	SRS	Total
Pu-238	7.89E+05	2.25E+05	3.62E+05	1.14E+04	1.03E+06	2.42E+06
Pu-241	3.79E+05	4.60E+05	5.23E+03	1.51E+06	2.73E+05	2.63E+06
Pu-239	2.58E+05	1.27E+05	2.50E+05	2.68E+05	2.23E+04	9.25E+05
Am-241	4.71E+04	2.75E+05	3.69E+04	2.12E+05	6.57E+03	5.77E+05
Pu-240	6.05E+04	3.02E+04	3.27E+02	1.08E+05	5.81E+03	2.05E+05
Cs-137	6.69E+03	2.28E+02	1.53E+02	0.00E+00	1.97E+01	1.02E+04
Ba-137m	6.33E+03	2.15E+02	1.44E+02	0.00E+00	1.86E+01	9.65E+03
Cm-244	1.01E+03	1.77E+03	4.95E+02	0.00E+00	3.58E+03	6.85E+03
Y-90	6.78E+03	3.82E+01	1.41E+02	0.00E+00	1.99E+03	8.95E+03
Sr-90	6.78E+03	3.82E+01	1.41E+02	0.00E+00	1.99E+03	8.95E+03
U-233	7.84E+02	2.74E+03	1.41E+02	1.23E+02	2.49E+02	4.04E+03
Pu-242	3.86E+00	9.91E+00	1.53E+03	9.11E-04	3.67E+00	1.55E+03
U-234	5.27E+02	2.02E+01	1.92E+01	4.55E-02	6.85E+01	6.35E+02
Pa-233	2.67E+00	3.52E+00	1.19E-01	1.61E-01	1.72E+01	2.37E+01
Np-237	2.67E+00	3.52E+00	1.19E-01	1.61E-01	1.72E+01	2.37E+01
Co-60	0.00E+00	1.90E+02	1.61E-02	0.00E+00	9.75E-01	1.91E+02
Eu-155	1.03E-02	1.93E+00	7.75E-01	0.00E+00	9.75E+01	1.00E+02
Cf-252	3.45E+02	5.35E-01	9.17E-03	0.00E+00	1.06E+00	3.47E+02
Pb-212	5.08E-01	7.97E+01	2.63E-02	0.00E+00	5.30E-01	8.08E+01
Ra-224	5.08E-01	7.97E+01	1.10E-02	0.00E+00	5.30E-01	8.08E+01
Bi-212	5.08E-01	7.97E+01	1.10E-02	0.00E+00	5.30E-01	8.08E+01
Po-216	5.08E-01	7.97E+01	1.10E-02	0.00E+00	5.30E-01	8.08E+01
Rn-220	5.08E-01	7.97E+01	1.10E-02	0.00E+00	5.30E-01	8.08E+01
Th-228	5.08E-01	7.97E+01	1.10E-02	0.00E+00	5.30E-01	8.08E+01
U-232	0.00E+00	7.70E+01	1.19E-02	0.00E+00	6.82E-01	7.77E+01
Np-239	1.14E+00	2.70E+00	1.21E+01	0.00E+00	2.30E+01	3.89E+01
Am-243	1.14E+00	2.65E+00	1.21E+01	0.00E+00	1.86E+01	3.45E+01
Tc-99	9.32E-05	2.61E-01	3.69E-02	0.00E+00	2.38E+01	2.41E+01
Po-212	3.26E-01	5.11E+01	7.04E-03	0.00E+00	3.39E-01	5.18E+01
Cm-245	1.64E+02	2.40E-01	4.31E-03	0.00E+00	8.57E-02	1.65E+02
Tl-208	1.83E-01	2.86E+01	3.95E-03	0.00E+00	1.90E-01	2.90E+01
U-237	9.29E+00	1.12E+01	1.28E-01	1.21E+01	4.41E+00	3.72E+01
Ra-226	1.10E-01	5.11E-01	2.86E+00	0.00E+00	8.74E+00	1.22E+01
Po-218	1.10E-01	5.10E-01	2.86E+00	0.00E+00	8.68E+00	1.22E+01
Rn-222	1.10E-01	5.10E-01	2.86E+00	0.00E+00	8.68E+00	1.22E+01
Bi-214	1.10E-01	5.10E-01	2.86E+00	0.00E+00	8.68E+00	1.22E+01
Pb-214	1.10E-01	5.10E-01	2.86E+00	0.00E+00	8.68E+00	1.22E+01
Po-214	1.10E-01	5.10E-01	2.86E+00	0.00E+00	8.67E+00	1.22E+01
Ag-109m	0.00E+00	9.36E-02	2.07E+01	0.00E+00	3.35E-02	2.08E+01
Cd-109	0.00E+00	9.36E-02	2.07E+01	0.00E+00	3.34E-02	2.08E+01
Pa-234m	5.76E+01	4.37E-01	7.67E-02	0.00E+00	9.82E-02	5.82E+01
Th-234	5.76E+01	4.37E-01	7.62E-02	0.00E+00	9.82E-02	5.82E+01
U-238	5.76E+01	4.37E-01	7.62E-02	0.00E+00	9.82E-02	5.82E+01
Pm-147	4.68E-01	8.11E+00	6.33E+00	0.00E+00	5.03E-02	1.50E+01
U-235	1.68E+01	2.32E-01	1.66E+00	4.52E-04	4.04E-02	1.87E+01
Th-231	1.68E+01	2.20E-01	1.66E+00	4.52E-04	4.19E-02	1.87E+01
Ac-225	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.86E-01	6.45E+00
Th-229	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.85E-01	6.45E+00
Ra-225	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.85E-01	6.45E+00
At-217	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.85E-01	6.45E+00
Bi-213	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.85E-01	6.45E+00
Fr-221	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.85E-01	6.45E+00
Pb-209	1.28E+00	4.63E+00	2.55E-01	0.00E+00	2.85E-01	6.45E+00
Po-213	1.25E+00	4.53E+00	2.50E-01	0.00E+00	2.79E-01	6.31E+00
C-14	1.57E+01	5.29E-01	4.53E-04	0.00E+00	9.01E-03	1.62E+01
Bi-210	2.93E-02	1.73E-01	8.86E-01	0.00E+00	1.69E+00	2.78E+00
Po-210	2.93E-02	1.73E-01	8.86E-01	0.00E+00	1.69E+00	2.78E+00
Pb-210	2.93E-02	1.73E-01	8.86E-01	0.00E+00	1.69E+00	2.78E+00
Eu-152	1.41E-05	1.59E+00	1.63E-03	0.00E+00	7.06E-03	1.60E+00
Cm-243	1.49E-01	1.60E-02	3.50E+00	0.00E+00	5.73E-03	3.67E+00
Eu-154	6.12E-04	2.40E+00	7.77E-02	0.00E+00	6.12E-03	2.48E+00

Table A-32
Radionuclide Inventories (Ci) for CH-TRU Waste by Treatment Site for Action Alternative 2B

Isotope	Hanford	INEL	SRS	Total
Pu-238	7.89E+05	5.99E+05	1.03E+06	2.42E+06
Pu-241	3.79E+05	1.98E+06	2.73E+05	2.63E+06
Pu-239	2.58E+05	6.45E+05	2.23E+04	9.25E+05
Am-241	4.71E+04	5.24E+05	6.57E+03	5.77E+05
Pu-240	6.05E+04	1.39E+05	5.81E+03	2.05E+05
Cs-137	6.69E+03	3.80E+02	1.97E+01	1.02E+04
Ba-137m	6.33E+03	3.60E+02	1.86E+01	9.65E+03
Cm-244	1.01E+03	2.26E+03	3.58E+03	6.85E+03
Y-90	6.78E+03	1.79E+02	1.99E+03	8.95E+03
Sr-90	6.78E+03	1.79E+02	1.99E+03	8.95E+03
U-233	7.84E+02	3.00E+03	2.49E+02	4.04E+03
Pu-242	3.86E+00	1.54E+03	3.67E+00	1.55E+03
U-234	5.27E+02	3.95E+01	6.85E+01	6.35E+02
Pa-233	2.67E+00	3.80E+00	1.72E+01	2.37E+01
Np-237	2.67E+00	3.80E+00	1.72E+01	2.37E+01
Co-60	0.00E+00	1.90E+02	9.75E-01	1.91E+02
Eu-155	1.03E-02	2.70E+00	9.75E+01	1.00E+02
Cf-252	3.45E+02	5.44E-01	1.06E+00	3.47E+02
Pb-212	5.08E-01	7.98E+01	5.30E-01	8.08E+01
Ra-224	5.08E-01	7.97E+01	5.30E-01	8.08E+01
Bi-212	5.08E-01	7.97E+01	5.30E-01	8.08E+01
Po-216	5.08E-01	7.97E+01	5.30E-01	8.08E+01
Rn-220	5.08E-01	7.97E+01	5.30E-01	8.08E+01
Th-228	5.08E-01	7.97E+01	5.30E-01	8.08E+01
U-232	0.00E+00	7.70E+01	6.82E-01	7.77E+01
Np-239	1.14E+00	1.48E+01	2.30E+01	3.89E+01
Am-243	1.14E+00	1.47E+01	1.86E+01	3.45E+01
Tc-99	9.32E-05	2.98E-01	2.38E+01	2.41E+01
Po-212	3.26E-01	5.11E+01	3.39E-01	5.18E+01
Cm-245	1.64E+02	2.44E-01	8.57E-02	1.65E+02
Tl-208	1.83E-01	2.86E+01	1.90E-01	2.90E+01
U-237	9.29E+00	2.35E+01	4.41E+00	3.72E+01
Ra-226	1.10E-01	3.37E+00	8.74E+00	1.22E+01
Po-218	1.10E-01	3.37E+00	8.68E+00	1.22E+01
Rn-222	1.10E-01	3.37E+00	8.68E+00	1.22E+01
Bi-214	1.10E-01	3.37E+00	8.68E+00	1.22E+01
Pb-214	1.10E-01	3.37E+00	8.68E+00	1.22E+01
Po-214	1.10E-01	3.37E+00	8.67E+00	1.22E+01
Ag-109m	0.00E+00	2.08E+01	3.35E-02	2.08E+01
Cd-109	0.00E+00	2.08E+01	3.34E-02	2.08E+01
Pa-234m	5.76E+01	5.14E-01	9.82E-02	5.82E+01
Th-234	5.76E+01	5.14E-01	9.82E-02	5.82E+01
U-238	5.76E+01	5.13E-01	9.82E-02	5.82E+01
Pm-147	4.68E-01	1.44E+01	5.03E-02	1.50E+01
U-235	1.68E+01	1.90E+00	4.04E-02	1.87E+01
Th-231	1.68E+01	1.88E+00	4.19E-02	1.87E+01
Ac-225	1.28E+00	4.88E+00	2.86E-01	6.45E+00
Th-229	1.28E+00	4.88E+00	2.85E-01	6.45E+00
Ra-225	1.28E+00	4.88E+00	2.85E-01	6.45E+00
At-217	1.28E+00	4.88E+00	2.85E-01	6.45E+00
Bi-213	1.28E+00	4.88E+00	2.85E-01	6.45E+00
Fr-221	1.28E+00	4.88E+00	2.85E-01	6.45E+00
Pb-209	1.28E+00	4.88E+00	2.85E-01	6.45E+00
Po-213	1.25E+00	4.78E+00	2.79E-01	6.31E+00
C-14	1.57E+01	5.30E-01	9.01E-03	1.62E+01
Bi-210	2.93E-02	1.06E+00	1.69E+00	2.78E+00
Po-210	2.93E-02	1.06E+00	1.69E+00	2.78E+00
Pb-210	2.93E-02	1.06E+00	1.69E+00	2.78E+00
Eu-152	1.41E-05	1.59E+00	7.06E-03	1.60E+00
Cm-243	1.49E-01	3.51E+00	5.73E-03	3.67E+00
Eu-154	6.12E-04	2.48E+00	6.12E-03	2.48E+00

Table A-33
Radionuclide Inventories (Ci) for RH-TRU Waste by Treatment Site for Action Alternatives 2A, 2B, and 2C

Isotope	Hanford	ORNL	Total
Y-90	1.00E+06	5.38E+04	1.06E+06
Sr-90	1.00E+06	5.38E+04	1.06E+06
Cs-137	1.07E+06	1.67E+04	1.09E+06
Ba-137m	1.01E+06	1.58E+04	1.03E+06
Pu-241	7.06E+05	8.45E+02	7.07E+05
Eu-152	1.92E+03	5.39E+03	7.31E+03
Eu-154	9.33E+02	2.62E+03	3.55E+03
Cm-244	5.79E+02	1.42E+03	2.00E+03
Co-60	5.13E+04	9.69E+02	5.22E+04
Pu-239	5.12E+04	2.27E+02	5.15E+04
Am-241	2.95E+04	4.02E+02	2.99E+04
Eu-155	1.93E+02	5.17E+02	7.10E+02
Pu-240	2.53E+04	3.57E+01	2.53E+04
Th-231	1.19E+02	2.73E+02	3.93E+02
U-235	1.19E+02	2.73E+02	3.93E+02
Pu-238	7.33E+03	1.84E+02	7.51E+03
Cm-243	7.77E+01	2.18E+02	2.96E+02
Cs-134	1.98E+02	5.62E+01	2.54E+02
U-233	9.41E+01	8.44E+01	1.79E+02
Pm-147	1.04E+02	3.51E+01	1.39E+02
Rh-106	1.87E+01	5.07E+01	6.94E+01
Ru-106	1.87E+01	5.07E+01	6.94E+01
Pr-144	2.27E+01	3.34E+01	5.61E+01
Ce-144	2.12E+01	2.91E+01	5.03E+01
C-14	3.34E+00	8.99E+00	1.23E+01
Kr-85	2.10E+01	1.06E+00	2.21E+01
Sb-125	1.55E+01	4.34E+00	1.98E+01
Cf-252	2.02E+00	5.67E+00	7.69E+00
Ni-63	1.24E+01	6.23E-01	1.30E+01
U-238	3.33E+00	4.96E+00	8.29E+00
Pa-234m	3.32E+00	4.96E+00	8.28E+00
Th-234	3.32E+00	4.96E+00	8.28E+00
U-232	9.25E-01	2.59E+00	3.52E+00
Po-216	1.11E+00	2.47E+00	3.57E+00
Bi-212	1.10E+00	2.46E+00	3.57E+00
Pb-212	1.10E+00	2.46E+00	3.57E+00
Ra-224	1.10E+00	2.46E+00	3.57E+00
Rn-220	1.10E+00	2.46E+00	3.57E+00
Th-228	1.10E+00	2.46E+00	3.57E+00
U-234	1.96E+02	2.63E-01	1.96E+02
Po-212	7.07E-01	1.58E+00	2.29E+00
Te-125m	3.80E+00	1.06E+00	4.87E+00

Table A-34
Radionuclide Inventories (Ci) for CH-TRU Waste by Treatment Site for Action Alternative 3

Isotope	Hanford	INEL	LANL	RFETS	SRS	Total
Pu-238	7.88E+05	2.24E+05	3.62E+05	1.14E+04	1.03E+06	2.41E+06
Pu-241	3.78E+05	4.57E+05	5.23E+03	1.51E+06	2.73E+05	2.62E+06
Pu-239	2.58E+05	1.26E+05	2.50E+05	2.68E+05	2.23E+04	9.24E+05
Am-241	4.70E+04	2.73E+05	3.69E+04	2.12E+05	6.57E+03	5.76E+05
Pu-240	6.04E+04	3.00E+04	3.27E+02	1.08E+05	5.81E+03	2.05E+05
Cs-137	6.68E+03	2.27E+02	1.53E+02	0.00E+00	1.97E+01	1.02E+04
Ba-137m	6.32E+03	2.14E+02	1.44E+02	0.00E+00	1.86E+01	9.63E+03
Cm-244	1.01E+03	1.76E+03	4.95E+02	0.00E+00	3.58E+03	6.84E+03
Y-90	6.77E+03	3.82E+01	1.41E+02	0.00E+00	1.99E+03	8.94E+03
Sr-90	6.77E+03	3.82E+01	1.41E+02	0.00E+00	1.99E+03	8.93E+03
U-233	7.82E+02	2.72E+03	1.41E+02	1.23E+02	2.49E+02	4.02E+03
Pu-242	3.85E+00	9.89E+00	1.53E+03	9.11E-04	3.67E+00	1.55E+03
U-234	5.26E+02	2.01E+01	1.92E+01	4.55E-02	6.85E+01	6.33E+02
Pa-233	2.66E+00	3.51E+00	1.19E-01	1.61E-01	1.72E+01	2.36E+01
Np-237	2.66E+00	3.51E+00	1.19E-01	1.61E-01	1.72E+01	2.36E+01
Co-60	0.00E+00	1.89E+02	1.61E-02	0.00E+00	9.75E-01	1.90E+02
Eu-155	1.03E-02	1.92E+00	7.75E-01	0.00E+00	9.75E+01	1.00E+02
Cf-252	3.45E+02	5.35E-01	9.17E-03	0.00E+00	1.06E+00	3.46E+02
Pb-212	5.07E-01	7.93E+01	2.63E-02	0.00E+00	5.30E-01	8.04E+01
Ra-224	5.07E-01	7.93E+01	1.10E-02	0.00E+00	5.30E-01	8.04E+01
Bi-212	5.07E-01	7.93E+01	1.10E-02	0.00E+00	5.30E-01	8.04E+01
Po-216	5.07E-01	7.93E+01	1.10E-02	0.00E+00	5.30E-01	8.04E+01
Rn-220	5.07E-01	7.93E+01	1.10E-02	0.00E+00	5.30E-01	8.04E+01
Th-228	5.07E-01	7.93E+01	1.10E-02	0.00E+00	5.30E-01	8.04E+01
U-232	0.00E+00	7.66E+01	1.19E-02	0.00E+00	6.82E-01	7.73E+01
Np-239	1.13E+00	2.69E+00	1.21E+01	0.00E+00	2.30E+01	3.89E+01
Am-243	1.13E+00	2.65E+00	1.21E+01	0.00E+00	1.86E+01	3.45E+01
Tc-99	9.30E-05	2.61E-01	3.69E-02	0.00E+00	2.38E+01	2.41E+01
Po-212	3.25E-01	5.08E+01	7.04E-03	0.00E+00	3.39E-01	5.15E+01
Cm-245	1.64E+02	2.40E-01	4.31E-03	0.00E+00	8.57E-02	1.64E+02
Tl-208	1.82E-01	2.85E+01	3.95E-03	0.00E+00	1.90E-01	2.89E+01
U-237	9.27E+00	1.12E+01	1.28E-01	1.21E+01	4.41E+00	3.71E+01
Ra-226	1.10E-01	5.10E-01	2.86E+00	0.00E+00	8.74E+00	1.22E+01
Po-218	1.10E-01	5.09E-01	2.86E+00	0.00E+00	8.68E+00	1.22E+01
Rn-222	1.10E-01	5.09E-01	2.86E+00	0.00E+00	8.68E+00	1.22E+01
Bi-214	1.10E-01	5.09E-01	2.86E+00	0.00E+00	8.68E+00	1.22E+01
TPb-214	1.10E-01	5.09E-01	2.86E+00	0.00E+00	8.68E+00	1.22E+01
Po-214	1.10E-01	5.09E-01	2.86E+00	0.00E+00	8.67E+00	1.22E+01
Ag-109m	0.00E+00	9.36E-02	2.07E+01	0.00E+00	3.35E-02	2.08E+01
Cd-109	0.00E+00	9.36E-02	2.07E+01	0.00E+00	3.34E-02	2.08E+01
Pa-234m	5.74E+01	4.36E-01	7.67E-02	0.00E+00	9.82E-02	5.81E+01
Th-234	5.74E+01	4.35E-01	7.62E-02	0.00E+00	9.82E-02	5.81E+01
U-238	5.74E+01	4.35E-01	7.62E-02	0.00E+00	9.82E-02	5.81E+01
Pm-147	4.67E-01	8.07E+00	6.33E+00	0.00E+00	5.03E-02	1.49E+01
U-235	1.67E+01	2.31E-01	1.66E+00	4.52E-04	4.04E-02	1.87E+01
Th-231	1.67E+01	2.19E-01	1.66E+00	4.52E-04	4.19E-02	1.87E+01
Ac-225	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.86E-01	6.42E+00
Th-229	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.85E-01	6.42E+00
Ra-225	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.85E-01	6.42E+00
At-217	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.85E-01	6.42E+00
Bi-213	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.85E-01	6.42E+00
Fr-221	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.85E-01	6.42E+00
Pb-209	1.28E+00	4.60E+00	2.55E-01	0.00E+00	2.85E-01	6.42E+00
Po-213	1.25E+00	4.50E+00	2.50E-01	0.00E+00	2.79E-01	6.28E+00
C-14	1.56E+01	5.26E-01	4.53E-04	0.00E+00	9.01E-03	1.62E+01
Bi-210	2.93E-02	1.73E-01	8.86E-01	0.00E+00	1.69E+00	2.78E+00
Po-210	2.93E-02	1.73E-01	8.86E-01	0.00E+00	1.69E+00	2.78E+00
Pb-210	2.93E-02	1.73E-01	8.86E-01	0.00E+00	1.69E+00	2.78E+00
Eu-152	1.41E-05	1.59E+00	1.63E-03	0.00E+00	7.06E-03	1.59E+00
Cm-243	1.49E-01	1.60E-02	3.50E+00	0.00E+00	5.73E-03	3.67E+00
Eu-154	6.11E-04	2.39E+00	7.77E-02	0.00E+00	6.12E-03	2.47E+00

Table A-35
Radionuclide Inventories (Ci) for RH-TRU Waste by Treatment Site for Action Alternative 3

Isotope	Hanford	ORNL	Total
Y-90	1.00E+06	5.38E+04	1.06E+06
Sr-90	1.00E+06	5.38E+04	1.06E+06
Cs-137	1.07E+06	1.67E+04	1.09E+06
Ba-137m	1.01E+06	1.58E+04	1.03E+06
Pu-241	7.06E+05	8.45E+02	7.07E+05
Eu-152	1.92E+03	5.39E+03	7.31E+03
Eu-154	9.33E+02	2.62E+03	3.55E+03
Cm-244	5.79E+02	1.42E+03	2.00E+03
Co-60	5.13E+04	9.69E+02	5.22E+04
Pu-239	5.12E+04	2.27E+02	5.15E+04
Am-241	2.95E+04	4.02E+02	2.99E+04
Eu-155	1.93E+02	5.17E+02	7.10E+02
Pu-240	2.53E+04	3.57E+01	2.53E+04
Th-231	1.19E+02	2.73E+02	3.93E+02
U-235	1.19E+02	2.73E+02	3.93E+02
Pu-238	7.33E+03	1.84E+02	7.51E+03
Cm-243	7.77E+01	2.18E+02	2.96E+02
Cs-134	1.98E+02	5.62E+01	2.54E+02
U-233	9.41E+01	8.44E+01	1.79E+02
Pm-147	1.04E+02	3.51E+01	1.39E+02
Rh-106	1.87E+01	5.07E+01	6.94E+01
Ru-106	1.87E+01	5.07E+01	6.94E+01
Pr-144	2.27E+01	3.34E+01	5.61E+01
Ce-144	2.12E+01	2.91E+01	5.03E+01
C-14	3.34E+00	8.99E+00	1.23E+01
Kr-85	2.10E+01	1.06E+00	2.21E+01
Sb-125	1.55E+01	4.34E+00	1.98E+01
Cf-252	2.02E+00	5.67E+00	7.69E+00
Ni-63	1.24E+01	6.23E-01	1.30E+01
U-238	3.33E+00	4.96E+00	8.29E+00
Pa-234m	3.32E+00	4.96E+00	8.28E+00
Th-234	3.32E+00	4.96E+00	8.28E+00
U-232	9.25E-01	2.59E+00	3.52E+00
Po-216	1.11E+00	2.47E+00	3.57E+00
Bi-212	1.10E+00	2.46E+00	3.57E+00
Pb-212	1.10E+00	2.46E+00	3.57E+00
Ra-224	1.10E+00	2.46E+00	3.57E+00
Rn-220	1.10E+00	2.46E+00	3.57E+00
Th-228	1.10E+00	2.46E+00	3.57E+00
U-234	1.96E+02	2.63E-01	1.96E+02
Po-212	7.07E-01	1.58E+00	2.29E+00
Te-125m	3.80E+00	1.06E+00	4.87E+00

A.4.7.1 CH-TRU Waste

The CH-TRU waste radionuclide inventory for the seven largest generator-storage sites under No Action Alternative 2 is given in Table A-36.

No Action Alternative 2 long-term performance calculations are initiated at the assumed time of loss of institutional control at the generator-storage sites. A decayed radionuclide inventory was required for long-term performance assessment calculations. The CH-TRU waste radionuclide inventory at treatment sites decayed to the year 2133 is given in Table A-37. Only those radionuclides with activities greater than 1 Ci and half-lives greater than approximately 10 minutes have been retained.

A.4.7.2 RH-TRU Waste

The RH-TRU waste radionuclide inventory at each treatment site for No Action Alternative 2 is given in Table A-38. Again, No Action Alternative 2 long-term performance calculations require the use of a decayed radionuclide inventory to account for the 100 years after WIPP would have ceased operation. These values are given in Table A-39. Only those radionuclides with activities greater than 1 Ci and half-lives greater than approximately 10 minutes have been retained.

A.5 HAZARDOUS CONSTITUENTS INVENTORY

TRU mixed waste is defined as any TRU waste that is commingled with a hazardous waste regulated by RCRA (40 CFR 261, Subparts C and D). There are two classes of RCRA-regulated constituents of concern relative to WIPP, metals and volatile organic compounds (VOC). For the purposes of conducting analyses that bound adverse impacts, all TRU wastes to be emplaced in WIPP were assumed to be TRU mixed waste. As compared with the approximate 60 percent of the volume of stored waste classified as TRU mixed wastes (see Table A-16). No attempt was made to forecast future operational procedures at generator-storage sites that would treat TRU and TRU mixed waste streams differently.

A.5.1 Metals Inventory

BIR-2 does not contain detailed information on hazardous constituents. An inventory of hazardous metals, however, was developed for fire and explosion accident scenarios in the SAR (DOE 1995b, Table 5.1-2). These inventory values, which correspond to a 110-kilogram (243-pound) drum, are: 0.023 kilograms (0.051 pounds) for beryllium; 3.3×10^{-4} kilograms (7.3×10^{-4} pounds) for cadmium; 0.91 kilograms (2 pounds) for lead; and 0.39 kilograms (0.86 pounds) for mercury.

Using the average material parameter data in BIR-2, a drum of CH-TRU waste is expected to contain approximately 120 kilograms (265 pounds) of waste. Similarly, a drum of RH-TRU waste is expected to contain 105 kilograms (230 pounds) of waste. CH-TRU metal concentrations were adjusted from the 110-kilogram drum in SAR to the 120-kilogram drum for SEIS-II. Similarly, the RH-TRU metal concentrations were adjusted down to the 105-kilogram drum for SEIS-II. The BIR-2 lead inventory value of 464 kilograms per cubic meter (29 pounds per cubic feet), which includes lead for shielding, was used for the RH-TRU concentration. Concentrations of metals used in SEIS-II analyses for both CH-TRU and RH-TRU waste are listed in Table A-40.

Table A-36
Radionuclide Inventories (Ci) for CH-TRU Waste by Generator-Storage Site for No Action Alternative 2

Isotope	Hanford	INEL	LANL	LLNL	ORNL	RFETS	SRS
Pu-238	3.77E+05	7.18E+04	2.18E+05	3.97E+02	6.48E+03	1.14E+04	1.10E+06
Pu-241	1.77E+05	1.56E+05	3.18E+03	8.46E+03	6.23E+04	1.51E+06	2.24E+05
Pu-239	1.23E+05	4.26E+04	1.51E+05	8.52E+02	3.91E+03	2.68E+05	1.87E+04
Am-241	2.22E+04	9.18E+04	2.22E+04	7.46E+02	2.36E+03	2.12E+05	4.01E+03
Pu-240	2.88E+04	1.02E+04	1.99E+02	3.34E+02	1.28E+03	1.08E+05	4.61E+03
Cs-137	3.20E+03	1.05E+02	9.22E+01	8.62E-06	3.60E+00	0.00E+00	1.50E+01
Ba-137m	3.02E+03	9.93E+01	8.73E+01	8.16E-06	3.40E+00	0.00E+00	1.42E+01
Cm-244	3.20E+02	5.39E+02	2.98E+02	3.39E+02	1.37E+03	0.00E+00	2.33E+03
Y-90	3.24E+03	3.37E+01	8.51E+01	0.00E+00	1.89E+03	0.00E+00	1.40E+01
Sr-90	3.24E+03	3.37E+01	8.51E+01	0.00E+00	1.89E+03	0.00E+00	1.39E+01
U-233	3.74E+02	9.16E+02	8.52E+01	3.08E-08	2.29E+02	1.23E+02	7.50E+00
Pu-242	1.78E+00	7.91E+00	9.23E+02	1.05E-01	1.46E+00	9.11E-04	7.50E-01
U-234	2.52E+02	7.71E+00	1.16E+01	1.70E-02	2.03E+01	4.55E-02	5.11E+01
Pa-233	1.27E+00	1.79E+00	7.69E-02	2.44E-03	1.15E+00	1.61E-01	1.72E+01
Np-237	1.27E+00	1.79E+00	7.69E-02	2.44E-03	1.15E+00	1.61E-01	1.72E+01
Co-60	0.00E+00	6.33E+01	1.49E-02	0.00E+00	1.49E-01	0.00E+00	7.11E-01
Eu-155	4.94E-03	1.15E+00	4.71E-01	0.00E+00	1.27E-01	0.00E+00	1.06E+02
Cf-252	1.65E+02	5.13E-01	8.50E-03	0.00E+00	2.90E-01	0.00E+00	7.23E-01
Pb-212	2.43E-01	2.66E+01	1.80E-02	0.00E+00	4.26E-01	0.00E+00	1.84E-02
Ra-224	2.43E-01	2.66E+01	8.83E-03	0.00E+00	4.26E-01	0.00E+00	1.84E-02
Bi-212	2.43E-01	2.66E+01	8.83E-03	0.00E+00	4.26E-01	0.00E+00	1.84E-02
Po-216	2.43E-01	2.66E+01	8.83E-03	0.00E+00	4.26E-01	0.00E+00	1.84E-02
Rn-220	2.43E-01	2.66E+01	8.83E-03	0.00E+00	4.26E-01	0.00E+00	1.84E-02
Th-228	2.43E-01	2.66E+01	8.83E-03	0.00E+00	4.26E-01	0.00E+00	1.84E-02
U-232	0.00E+00	2.57E+01	9.29E-03	0.00E+00	4.33E-01	0.00E+00	1.79E-01
Np-239	4.22E-01	6.84E-01	7.29E+00	1.27E-01	1.91E+01	0.00E+00	1.51E+00
Am-243	4.22E-01	6.37E-01	7.28E+00	1.27E-01	1.49E+01	0.00E+00	1.51E+00
Tc-99	4.45E-05	2.57E-01	2.37E-02	0.00E+00	2.28E+01	0.00E+00	8.99E-06
Po-212	1.56E-01	1.70E+01	5.66E-03	0.00E+00	2.73E-01	0.00E+00	1.18E-02
Cm-245	7.86E+01	2.40E-01	3.99E-03	0.00E+00	3.99E-02	0.00E+00	0.00E+00
Tl-208	8.72E-02	9.56E+00	3.17E-03	0.00E+00	1.53E-01	0.00E+00	6.60E-03
U-237	4.34E+00	3.80E+00	7.78E-02	2.07E-01	1.53E+00	1.21E+01	3.04E+00
Ra-226	1.48E-04	1.59E-01	1.72E+00	2.07E-07	8.39E+00	0.00E+00	1.46E-05
Po-218	1.48E-04	1.58E-01	1.72E+00	0.00E+00	8.33E+00	0.00E+00	1.46E-05
Rn-222	1.48E-04	1.58E-01	1.72E+00	0.00E+00	8.33E+00	0.00E+00	1.46E-05
Bi-214	1.48E-04	1.58E-01	1.72E+00	0.00E+00	8.33E+00	0.00E+00	1.46E-05
Pb-214	1.48E-04	1.58E-01	1.72E+00	0.00E+00	8.33E+00	0.00E+00	1.46E-05
Po-214	1.47E-04	1.58E-01	1.72E+00	0.00E+00	8.32E+00	0.00E+00	1.46E-05
Ag-109m	0.00E+00	9.36E-02	1.25E+01	0.00E+00	1.56E-02	0.00E+00	0.00E+00
Cd-109	0.00E+00	9.36E-02	1.25E+01	0.00E+00	1.55E-02	0.00E+00	0.00E+00
Pa-234m	2.74E+01	2.03E-01	4.67E-02	1.57E-01	6.89E-02	0.00E+00	1.14E-02
Th-234	2.74E+01	2.03E-01	4.64E-02	1.57E-01	6.89E-02	0.00E+00	1.14E-02
U-238	2.74E+01	2.03E-01	4.64E-02	1.57E-01	6.89E-02	0.00E+00	1.14E-02
Pm-147	2.24E-01	2.69E+00	3.82E+00	0.00E+00	3.62E-02	0.00E+00	2.47E-05
U-235	8.00E+00	9.51E-02	1.00E+00	3.08E-03	2.26E-02	4.52E-04	1.17E-02
Th-231	8.00E+00	9.49E-02	1.00E+00	9.15E-03	2.41E-02	4.52E-04	1.17E-02
Ac-225	6.12E-01	1.55E+00	1.54E-01	0.00E+00	2.70E-01	0.00E+00	2.61E-05
Th-229	6.12E-01	1.55E+00	1.54E-01	0.00E+00	2.69E-01	0.00E+00	2.61E-05
Ra-225	6.12E-01	1.55E+00	1.54E-01	0.00E+00	2.69E-01	0.00E+00	2.61E-05
At-217	6.12E-01	1.55E+00	1.54E-01	0.00E+00	2.69E-01	0.00E+00	2.61E-05
Bi-213	6.12E-01	1.55E+00	1.54E-01	0.00E+00	2.69E-01	0.00E+00	2.61E-05
Fr-221	6.12E-01	1.55E+00	1.54E-01	0.00E+00	2.69E-01	0.00E+00	2.61E-05
Pb-209	6.12E-01	1.55E+00	1.54E-01	0.00E+00	2.69E-01	0.00E+00	2.61E-05
Po-213	5.98E-01	1.51E+00	1.51E-01	0.00E+00	2.64E-01	0.00E+00	2.56E-05
C-14	7.49E+00	1.92E-01	4.20E-04	0.00E+00	4.19E-03	0.00E+00	0.00E+00
Bi-210	2.48E-05	5.05E-02	5.34E-01	0.00E+00	1.62E+00	0.00E+00	2.22E-06
Po-210	2.48E-05	5.05E-02	5.34E-01	0.00E+00	1.62E+00	0.00E+00	2.22E-06
Pb-210	2.48E-05	5.05E-02	5.34E-01	0.00E+00	1.62E+00	0.00E+00	2.22E-06
Eu-152	3.43E-06	1.80E-01	1.09E-03	6.90E-06	3.69E-03	0.00E+00	0.00E+00
Cm-243	7.12E-02	1.60E-02	2.11E+00	0.00E+00	2.66E-03	0.00E+00	0.00E+00
Eu-154	2.91E-04	6.59E-01	4.69E-02	2.72E-06	2.60E-03	0.00E+00	5.68E-04

Table A-37
Decayed Radionuclide Inventories (Ci) Adjusted for Decay Through 2133 for CH-TRU Waste by Generator-Storage Site for No Action Alternative 2

Isotopes	Hanford	INEL	LANL	LLNL	ORNL	RFETS	SRS
Pu-238	1.71E+05	3.26E+04	9.88E+04	1.80E+02	2.94E+03	5.17E+03	4.99E+05
Pu-239	1.23E+05	4.25E+04	1.51E+05	8.50E+02	3.90E+03	2.67E+05	1.87E+04
Am-241	2.41E+04	8.27E+04	1.90E+04	8.81E+02	3.82E+03	2.25E+05	9.93E+03
Pu-240	2.85E+04	1.01E+04	1.98E+02	3.31E+02	1.27E+03	1.07E+05	4.57E+03
Pu-241	1.52E+03	1.27E+03	2.58E+01	6.87E+01	5.06E+02	1.23E+04	1.82E+03
Pu-242	1.78E+00	7.91E+00	9.23E+02	1.05E-01	1.46E+00	9.11E-04	7.50E-01
U-233	3.74E+02	9.16E+02	8.52E+01	1.10E-06	2.29E+02	1.23E+02	7.50E+00
U-234	3.26E+02	2.18E+01	5.43E+01	9.48E-02	2.16E+01	2.28E+00	2.67E+02
Cs-137	3.20E+02	1.05E+01	9.23E+00	8.63E-07	2.86E-01	0.00E+00	1.50E+00
Y-90	2.97E+02	3.09E+00	7.81E+00	0.00E+00	1.74E+02	0.00E+00	1.28E+00
Sr-90	2.97E+02	3.09E+00	7.81E+00	0.00E+00	1.74E+02	0.00E+00	1.28E+00
Cm-245	7.80E+01	2.38E-01	3.96E-03	0.00E+00	3.96E-02	0.00E+00	0.00E+00
Cm-244	6.95E+00	1.17E+01	6.47E+00	7.36E+00	2.97E+01	0.00E+00	5.06E+01
Th-234	2.74E+01	2.03E-01	4.64E-02	1.57E-01	6.89E-02	0.00E+00	1.14E-02
U-238	2.74E+01	2.03E-01	4.64E-02	1.57E-01	6.89E-02	0.00E+00	1.14E-02
Tc-99	4.45E-05	2.57E-01	2.37E-02	0.00E+00	2.28E+01	0.00E+00	8.99E-06
Pa-233	1.27E+00	1.79E+00	7.69E-02	2.44E-03	1.15E+00	1.61E-01	1.72E+01
Np-237	1.27E+00	1.79E+00	7.69E-02	2.44E-03	1.15E+00	1.61E-01	1.72E+01
Np-239	4.18E-01	6.31E-01	7.21E+00	1.26E-01	1.48E+01	0.00E+00	1.50E+00
Am-243	4.18E-01	6.31E-01	7.21E+00	1.26E-01	1.48E+01	0.00E+00	1.50E+00
Th-229	4.12E+00	1.02E+01	9.53E-01	5.31E-09	2.42E+00	1.16E+00	7.06E-02
Ra-225	4.12E+00	1.01E+01	9.53E-01	5.31E-09	2.42E+00	1.16E+00	7.05E-02
Ac-225	4.12E+00	1.01E+01	9.53E-01	5.30E-09	2.42E+00	1.16E+00	7.05E-02
Pb-212	4.55E-17	1.01E+01	3.65E-03	0.00E+00	1.70E-01	0.00E+00	7.02E-02
Ra-224	4.55E-17	1.01E+01	3.65E-03	0.00E+00	1.70E-01	0.00E+00	7.02E-02
Th-228	4.53E-17	1.01E+01	3.65E-03	0.00E+00	1.70E-01	0.00E+00	7.02E-02
U-232	0.00E+00	9.81E+00	3.55E-03	0.00E+00	1.65E-01	0.00E+00	6.84E-02
Ra-226	5.56E-03	1.53E-01	1.65E+00	1.13E-06	8.03E+00	1.81E-05	2.66E-03
Rn-222	1.42E-04	1.52E-01	1.65E+00	1.99E-07	8.03E+00	0.00E+00	1.40E-05
U-235	8.00E+00	9.51E-02	1.00E+00	3.08E-03	2.26E-02	4.52E-04	1.17E-02
Th-231	8.00E+00	9.51E-02	1.00E+00	3.08E-03	2.26E-02	4.52E-04	1.17E-02
Pb-210	1.38E-04	1.50E-01	1.62E+00	1.92E-07	7.84E+00	0.00E+00	1.36E-05
Bi-210	1.38E-04	1.50E-01	1.62E+00	1.92E-07	7.84E+00	0.00E+00	1.36E-05
Po-210	1.38E-04	1.49E-01	1.62E+00	1.92E-07	7.84E+00	0.00E+00	1.36E-05
C-14	7.40E+00	1.90E-01	4.15E-04	0.00E+00	4.14E-03	0.00E+00	0.00E+00

Table A-38
Radionuclide Inventories (Ci) for RH-TRU Waste by Generator-Storage Site for No Action Alternative 2

Isotope	Hanford	INEL	LANL	ORNL	Total
Y-90	9.41E+05	2.45E+04	3.01E+02	5.16E+04	1.02E+06
Sr-90	9.41E+05	2.45E+04	3.00E+02	5.16E+04	1.02E+06
Cs-137	1.02E+06	1.18E+04	3.27E+02	1.55E+04	1.04E+06
Ba-137M	9.62E+05	1.12E+04	3.10E+02	1.47E+04	9.88E+05
Pu-241	6.79E+05	2.52E+03	0.00E+00	8.39E+02	6.83E+05
Eu-152	0.00E+00	1.92E+03	1.23E-03	5.22E+03	7.13E+03
Eu-154	0.00E+00	9.31E+02	8.47E-02	2.52E+03	3.46E+03
Cm-244	0.00E+00	5.79E+02	0.00E+00	1.37E+03	1.95E+03
Co-60	4.90E+04	5.21E+02	1.01E+01	9.38E+02	5.04E+04
Pu-239	4.88E+04	3.23E+02	2.25E+02	2.22E+02	4.96E+04
Am-241	2.81E+04	3.00E+02	0.00E+00	3.87E+02	2.88E+04
Eu-155	0.00E+00	1.85E+02	4.29E+00	5.00E+02	6.89E+02
Pu-240	2.43E+04	1.26E+02	0.00E+00	3.56E+01	2.44E+04
Th-231	2.13E+01	9.74E+01	2.13E-02	2.64E+02	3.83E+02
U-235	2.13E+01	9.74E+01	2.13E-02	2.64E+02	3.83E+02
Pu-238	6.80E+03	1.50E+02	9.44E+00	6.51E+01	7.03E+03
Cm-243	0.00E+00	7.77E+01	0.00E+00	2.11E+02	2.89E+02
Cs-134	0.00E+00	8.95E+01	5.85E-02	2.40E+01	1.14E+02
U-233	6.04E+01	3.08E+01	0.00E+00	8.17E+01	1.73E+02
Pm-147	0.00E+00	3.24E+01	2.73E+01	5.95E+00	6.57E+01
Rh-106	0.00E+00	1.74E+01	8.18E-01	4.59E+01	6.40E+01
Ru-106	0.00E+00	1.74E+01	8.18E-01	4.59E+01	6.40E+01
Pr-144	0.00E+00	1.47E+01	3.84E-02	2.24E+01	3.71E+01
Ce-144	0.00E+00	1.32E+01	3.88E-02	1.81E+01	3.13E+01
C-14	0.00E+00	3.26E+00	0.00E+00	8.70E+00	1.20E+01
Kr-85	0.00E+00	9.07E+00	0.00E+00	1.06E+00	1.01E+01
Sb-125	0.00E+00	3.24E+00	6.75E+00	7.66E-01	1.08E+01
Cf-252	0.00E+00	2.02E+00	0.00E+00	5.49E+00	7.51E+00
Ni-63	0.00E+00	5.34E+00	0.00E+00	6.23E-01	5.96E+00
U-238	1.49E+00	1.78E+00	4.84E-05	4.80E+00	8.07E+00
Pa-234m	1.49E+00	1.77E+00	4.84E-05	4.80E+00	8.06E+00
Th-234	1.49E+00	1.77E+00	4.84E-05	4.80E+00	8.06E+00
U-232	0.00E+00	9.24E-01	0.00E+00	2.51E+00	3.44E+00
Po-216	2.17E-01	8.84E-01	0.00E+00	2.39E+00	3.49E+00
Bi-212	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
Pb-212	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
Ra-224	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
Rn-220	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
Th-228	2.17E-01	8.79E-01	0.00E+00	2.38E+00	3.48E+00
U-234	1.88E+02	9.08E-01	2.69E-05	2.60E-01	1.89E+02
Po-212	1.39E-01	5.63E-01	0.00E+00	1.53E+00	2.23E+00
Te-125m	0.00E+00	7.93E-01	1.67E+00	1.88E-01	2.65E+00

Table A-39
Decayed Radionuclide Inventories (Ci) Adjusted for Decay Through 2133 for RH-TRU Waste by Generator-Storage Site for No Action Alternative 2

Isotope	Hanford	INEL	LANL	ORNL
Cs-137	1.02E+05	1.18E+03	3.27E+01	1.55E+03
Y-90	8.64E+04	2.25E+03	2.75E+01	4.75E+03
Sr-90	8.64E+04	2.25E+03	2.75E+01	4.75E+03
Pu-239	4.87E+04	3.22E+02	2.24E+02	2.22E+02
Am-241	4.37E+04	3.29E+02	0.00E+00	3.54E+02
Pu-240	2.40E+04	1.26E+02	0.00E+00	3.89E+01
Pu-241	5.52E+03	2.05E+01	0.00E+00	6.82E+00
Pu-238	3.08E+03	6.80E+01	4.28E+00	2.96E+01
Th-231	2.13E+01	9.74E+01	2.13E-02	2.65E+02
U-235	2.13E+01	9.74E+01	2.13E-02	2.65E+02
U-234	1.89E+02	9.38E-01	1.88E-03	2.74E-01
U-233	6.04E+01	3.08E+01	0.00E+00	8.17E+01
Cm-244	0.00E+00	1.26E+01	0.00E+00	2.97E+01
Eu-152	0.00E+00	1.06E+01	6.80E-06	2.88E+01
Cm-243	0.00E+00	6.81E+00	0.00E+00	1.85E+01
C-14	0.00E+00	3.22E+00	0.00E+00	8.61E+00
U-238	1.49E+00	1.78E+00	4.84E-05	4.80E+00
Th-234	1.49E+00	1.78E+00	4.84E-05	4.80E+00
Ni-63	0.00E+00	2.60E+00	0.00E+00	3.03E-01

Table A-40
Concentration of Hazardous Metals

Metal	CH-TRU Waste Inventory (kg/cubic meter)	RH-TRU Waste Inventory (kg/cubic meter)
Beryllium	1.21E-01	1.21E-01
Cadmium	1.73E-03	1.74E-03
Lead	4.79E+00	4.64E+02
Mercury	2.05E+00	2.05E+00

Total inventory values for hazardous metals analyzed in SEIS-II are given in Table A-41. These values are based on the metal concentration in Table A-40 as well as the Basic Inventory and Additional Inventory.

A.5.2 Inventory of Volatile Organic Compounds

Other than to indicate the presence of a relatively small volume of PCB-commingled waste, the BIR-2 database does not contain information on organic compounds. PCB-commingled waste is only considered under Action Alternative 2 and No Action Alternative 1. Further, PCB waste would be thermally treated, which would completely destroy the PCBs. Risk analyses, therefore, were not performed for PCB-commingled TRU waste.

The *Comment Responses and Revisions to the Resource Conservation and Recovery Act Part B Permit Application*, published after SAR, provided more recent headspace sampling data and was used to estimate concentrations of VOCs (DOE 1996a, Table C2-4). The permit application summarizes the results of a headspace sampling and analysis study conducted on RFETS CH-TRU waste. Approximately 930 drums of varying waste types were sampled. Average concentrations of the VOCs that present the greatest potential risk to human health are expressed as parts per million per volume (ppmv) in Table A-42. Where compounds were not detected in the sampling process, one-half of the detection limit was used for calculating average concentrations.

The average concentrations for the VOCs were computed for the various final TRU waste forms. SEIS-II volume data was divided into final TRU waste forms in order to compute a volume-weighted average concentration for the VOCs, according to site. The weighted average concentrations for CH-TRU waste under No Action Alternative 2 are given in Table A-43.

Concentrations of VOCs were directly used in the analyses and are given in Tables A-43 and A-44 for No Action Alternative 2. Both No Action Alternative 2 and the Proposed Action address disposal of the same waste; therefore, the same concentrations were appropriate for both. The same concentration was assumed to apply to all of the waste under Action Alternatives 1 and 3. Finally, the thermal processing assumed under Action Alternative 2 and No Action Alternative 1, removes any VOCs.

The RCRA Part B Permit Application sampling data were taken from drums containing CH-TRU waste. In the absence of further information, the same concentrations were assumed to apply to RH-TRU waste. The weighted average concentrations by site for RH-TRU waste for No Action Alternative 2 are given in Table A-44.

For analyses that require a total inventory, such as the groundwater analysis of No Action Alternative 2, headspace data were used to calculate a total inventory of organic contaminants. Rault's Law and the assumption that the maximum average quantity of organic liquid in TRU waste is 1-weight percent were used. The concentrations of volatile organic material in thermally treated waste forms were assumed to be zero, because these contaminants are removed during high-temperature processing. The calculated VOC inventories for both CH-TRU and RH-TRU waste according to site are shown in Tables A-45 and A-46.

Table A-41
Inventory (kilograms) of Hazardous Metals by Alternative

Alternatives	CH-TRU Waste	RH-TRU Waste	Total
Lead Inventory			
Proposed Action	8.08E+05	3.29E+06	4.09E+06
Action Alternative 1	1.31E+06	1.80E+06	1.93E+07
Action Alternative 2	1.31E+06	1.80E+06	1.93E+07
Action Alternative 3	1.31E+06	1.80E+06	1.93E+07
No Action Alternative 1	1.31E+06	1.80E+06	1.93E+07
No Action Alternative 2	6.46E+05	1.64E+06	1.70E+07
Beryllium Inventory			
Proposed Action	2.04E+04	8.58E+02	2.13E+04
Action Alternative 1	3.31E+04	4.70E+03	3.78E+04
Action Alternative 2	3.32E+04	4.70E+03	3.79E+04
Action Alternative 3	3.31E+04	4.70E+03	3.78E+04
No Action Alternative 1	3.32E+04	4.70E+03	3.79E+04
No Action Alternative 2	1.63E+04	4.27E+03	2.06E+04
Cadmium Inventory			
Proposed Action	2.93E+02	1.23E+01	3.05E+02
Action Alternative 1	4.75E+02	6.74E+01	5.42E+02
Action Alternative 2	4.76E+02	6.74E+01	5.43E+02
Action Alternative 3	4.75E+02	6.74E+01	5.42E+02
No Action Alternative 1	4.76E+02	6.74E+01	5.43E+02
No Action Alternative 2	2.34E+02	6.13E+01	2.96E+02
Mercury Inventory			
Proposed Action	3.46E+05	1.45E+04	3.61E+05
Action Alternative 1	5.61E+05	7.97E+04	6.40E+05
Action Alternative 2	5.62E+05	7.97E+04	6.42E+05
Action Alternative 3	5.61E+05	7.97E+04	6.40E+05
No Action Alternative 1	5.62E+05	7.97E+04	6.42E+05
No Action Alternative 2	2.77E+05	7.25E+04	3.49E+05

Table A-42
Average Concentrations (ppmv) of Volatile Organic Compounds as Reported from the RCRA Part B Permit Application

Final TRU Waste Form	Carbon Tetrachloride	Chlorobenzene	Chloroform	Methyl Ethyl Ketone	Methylene Chloride
Combustible	566.52	1.54	41.09	7.60	12.29
Filter	1.44	0.18	0.19	5.11	0.48
Graphite	0.10	0.03	0.06	8.09	0.91
Heterogeneous	91.07	9.46	18.99	62.05	143.13
Inorganic Non-Metal	3.27	0.16	1.03	7.29	2.56
Lead/Cadmium Metal	255.28	4.94	6.86	42.56	8.61
Salt	4.32	0.18	0.23	5.50	0.56
Soils	0	0	0	0	0
Solidified Inorganics	316.51	1.29	1.15	6.83	8.05
Solidified Organics	8,319.32	94.30	135.98	717.96	214.47
Uncategorized Metal	9.58	13.40	7.94	39.34	1,941.71

Final TRU Waste Form	1,1,2,2-Tetrachloroethane	Toluene	1,1-Dichloroethene	1,2-Dichloroethane	1,1,1-Trichloroethane
Combustible	96.25	1.75	1.98	1.57	7.38
Filter	16.08	0.14	0.32	0.26	11.63
Graphite	8.06	0.03	0.04	0.03	0.63
Heterogeneous	711.98	7.64	14.42	7.62	24.11
Inorganic Non-Metal	29.33	0.17	1.01	0.16	4.31
Lead/Cadmium Metal	510.47	4.89	11.62	5.23	8.97
Salt	4.86	0.04	0.17	0.04	5.04
Soils	0	0	0	0	0
Solidified Inorganics	125.09	1.26	2.45	1.06	6.26
Solidified Organics	4,543.96	81.87	88.25	81.40	204.59
Uncategorized Metal	126.88	7.06	7.52	7.02	29.03

Table A-43
Volume-Weighted Average Concentrations (ppmv) of Volatile Organic Compounds in CH-TRU Waste by Treatment Site for Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2 [a]

Volatile Organic Compound	Hanford	LANL	INEL	SRS	RFETS	ORNL	LLNL	NTS	Mound	ANL-E
Carbon Tetrachloride	60.20	271.20	372.68	122.89	274.93	90.19	152.06	93.09	22.44	28.93
Chlorobenzene	9.65	6.20	9.41	8.33	2.67	9.37	9.45	9.39	3.75	12.16
Chloroform	11.84	13.65	17.73	16.13	8.98	18.81	18.53	18.83	3.20	7.35
Methyl Ethyl Ketone	40.40	21.00	54.23	53.43	19.57	61.45	62.88	61.55	11.22	36.64
Methylene Chloride	964.63	753.36	480.29	157.99	91.73	141.75	133.50	141.92	532.07	1,734.17
1,1,2,2-Tetrachloroethane	309.63	128.16	452.87	613.68	141.52	705.13	692.38	706.71	41.00	128.39
Toluene	6.05	3.78	7.04	6.69	2.23	7.57	7.68	7.59	2.02	6.49
1,1-Dichloroethene	8.60	4.47	10.16	12.51	3.21	14.28	13.99	14.31	2.18	7.03
1,2-Dichloroethane	6.01	3.64	6.96	6.64	2.18	7.55	7.66	7.56	2.00	6.45
1,1,1-Trichloroethane	22.31	15.67	23.18	21.56	10.12	23.88	24.44	23.95	8.32	26.42

[a] Volatiles are assumed destroyed during thermal treatment in Action Alternative 2 and No Action Alternative 1.

Table A-44
Volume-Weighted Average Concentrations (ppmv) of Volatile Organic Compounds in RH-TRU Waste by Treatment Site for Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2 [a]

Volatile Organic Compound	Hanford	LANL	INEL	ORNL
Carbon Tetrachloride	26.13	212.58	119.03	172.05
Chlorobenzene	12.61	8.97	8.80	6.53
Chloroform	10.08	20.34	17.44	12.58
Methyl Ethyl Ketone	43.76	29.16	56.88	42.19
Methylene Chloride	1,586.14	1,161.64	172.75	94.56
1,1,2,2-Tetrachloroethane	241.67	145.58	638.56	500.94
Toluene	7.17	5.20	7.05	5.35
1,1-Dichloroethene	8.87	5.89	13.07	10.12
1,2-Dichloroethane	7.13	5.11	7.02	5.26
1,1,1-Trichloroethane	28.01	21.05	22.56	17.69

[a] Volatiles are assumed destroyed during thermal treatment in Action Alternative 2 and No Action Alternative 1.

Table A-45
Inventory (grams) of Volatile Organic Compounds in CH-TRU Waste for the Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2 [a]

Compound	Hanford	INEL	LANL	ORNL	RFETS	SRS	LLNL
Carbon Tetrachloride	139,660	438,499	230,351	6,730	120,509	59,830	7,333
Chloroform	20,560	15,608	8,674	1,050	2,946	5,878	669
1,1-Dichloroethylene	3,759	2,253	715	201	265	1,147	127
Methylene Chloride	698,580	176,405	199,743	3,302	12,551	24,010	2,010
1,1,2,2-Tetrachloroethane	16,234,213	12,042,561	2,460,196	1,189,188	1,401,930	6,752,290	754,557
Chlorobenzene	216,336	106,937	50,878	6,756	11,324	39,169	4,401
Methyl Ethyl Ketone	136,670	93,043	26,013	6,686	12,509	37,925	4,421
Toluene	56,419	33,311	12,894	2,272	3,939	13,090	1,489
1,2-Dichloroethane	24,633	14,463	5,461	994	1,691	5,705	652
1,1,1-Trichloroethane	47,554	25,053	12,230	1,637	4,074	9,645	1,083

[a] Volatiles are assumed destroyed during thermal treatment in Action Alternative 2 and No Action Alternative 1.

Table A-46
Inventory (grams) of Volatile Organic Compounds in RH-TRU Waste for the Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2 [a]

Compound	Hanford	INEL	LANL	ORNL
Carbon Tetrachloride	31,024	9,397	1,959	25,450
Chloroform	8,958	1,031	140	1,392
1,1-Dichloroethylene	1,983	194	10	282
Methylene Chloride	587,915	4,257	3,342	4,366
1,1,2,2-Tetrachloroethane	6,485,477	1,139,327	30,327	1,674,680
Chlorobenzene	144,586	6,712	798	9,323
Methyl Ethyl Ketone	75,757	6,547	392	9,100
Toluene	34,223	2,238	193	3,181
1,2-Dichloroethane	14,949	978	83	1,374
1,1,1-Trichloroethane	30,552	1,636	178	2,405

[a] Volatiles are assumed destroyed during thermal treatment in Action Alternative 2 and No Action Alternative 1.

A.6 REFERENCES CITED IN APPENDIX A

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APPENDIX B

APPENDIX B
SUMMARY OF THE DRAFT WASTE MANAGEMENT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT AND ITS USE IN DETERMINING HUMAN HEALTH IMPACTS

The *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS) (DOE 1995a) is a nationwide study examining the environmental impacts of managing five types of radioactive and hazardous wastes that result primarily from nuclear defense activities – the development, production, and testing of nuclear weapons at a variety of sites located around the United States. The five waste types are the following: low-level mixed waste, low-level waste, transuranic (TRU) waste, high-level waste, and hazardous waste.

For each waste-type system, facilities are needed to treat, store, and/or dispose of the waste. In the Draft WM PEIS, the Department of Energy (DOE or the Department) has not only examined, in an integrated fashion, the impacts of complex-wide waste management for each waste type but also the specific cumulative impacts for all the waste facilities at a given site. The Draft WM PEIS provides information on the impacts of various siting alternatives, which DOE will use in deciding where to locate additional treatment, storage, and/or disposal capacity for each waste type. However, the location of a facility at a selected site will not be decided until completion of a subsequent sitewide or project-specific National Environmental Policy Act (NEPA) review.

B.1 RELATIONSHIP OF DIFFERENT LEVELS OF NEPA DOCUMENTS

In accordance with DOE NEPA regulations, three types of NEPA documentation may be prepared: programmatic, sitewide, and project-level. Programmatic documents, such as the Draft WM PEIS, provide environmental input into decisions on broad agency actions, such as the adoption of new plans, programs, and policies to guide future actions. Sitewide NEPA documents, such as this document (SEIS-II), provide the opportunity for considering changes in the overall operating mode of a DOE site, including mission change, and provide a current environmental baseline at the site. Project-level NEPA documents evaluate the impacts of a specific project at a specific location on a site and are intended to provide environmental input into the manner in which the facility should be constructed and operated. Sitewide NEPA documents, which evaluate projects that could be implemented in the near-term at a site, may also serve as project-level NEPA documents for specified projects.

B.2 WASTE MANAGEMENT DECISIONS TO BE MADE BY DOE

The Draft WM PEIS is intended to provide environmental information to assist DOE in determining at which sites it should modify existing waste management facilities or construct new facilities. The TRU waste management facilities proposed in the Draft WM PEIS are treatment and storage facilities. DOE needs to identify sites for waste management facilities in order to protect public health and safety, comply with federal law, and minimize adverse effects to the environment. DOE intends to select sites for TRU waste treatment and storage facilities using the Final WM PEIS analysis but will not select the level of treatment needed. Treatment level decisions will be made using SEIS-II analyses. Specific locations for the waste management

facilities within a site will be selected on the basis of subsequent sitewide or project-level NEPA documents.

B.3 OVERVIEW OF THE DRAFT WM PEIS TRU WASTE ANALYSES

The following sections present an overview of information in the Draft WM PEIS that is relevant to SEIS-II.

B.3.1 TRU Waste

TRU waste analyzed in the Draft WM PEIS considers both contact-handled (CH) TRU and remote-handled (RH) TRU waste placed in retrievable storage across the DOE complex since 1970 and projected to be generated for 20 years. For the purposes of Draft WM PEIS analyses, DOE included the small amount of nondefense TRU waste.

In addition, approximately 60 percent of the TRU waste also contains hazardous constituents as defined by the Resource Conservation and Recovery Act (RCRA); this waste is called TRU mixed waste. For purposes of the Draft WM PEIS analyses, DOE assumed that the entire inventory of TRU waste was TRU mixed waste.

Management activities associated with TRU waste that are discussed in the Draft WM PEIS include (1) retrieving TRU waste from storage and transporting it to a treatment facility; (2) sorting and treating the TRU waste as appropriate, packaging the waste, and certifying the waste for shipment to the Waste Isolation Pilot Plant (WIPP) for disposal; (3) storing certified waste; and (4) transporting the TRU waste to WIPP for disposal. For all of its alternatives except its no action alternative, the Draft WM PEIS assumed that TRU waste would be disposed of at WIPP.

B.3.2 TRU Waste Generator Sites and Inventories

Sixteen sites are identified in the Draft WM PEIS that have or are expected to generate or manage TRU waste.

Major sites identified in the Draft WM PEIS include the following:

- Argonne National Laboratory-East (ANL-E) near Chicago, Illinois
- Hanford Site (Hanford) at Richland, Washington
- Idaho National Engineering Laboratory (INEL) near Idaho Falls, Idaho
- Lawrence Livermore National Laboratory (LLNL) near San Francisco, California
- Los Alamos National Laboratory (LANL) at Los Alamos, New Mexico
- Mound Plant (Mound) at Miamisburg, Ohio
- Nevada Test Site (NTS) near Las Vegas, Nevada

- Oak Ridge Reservation (ORR) at Oak Ridge, Tennessee (identified as Oak Ridge National Laboratory [ORNL] in SEIS-II)
- Rocky Flats Environmental Technology Site (RFETS) near Golden, Colorado
- Savannah River Site (SRS) at Aiken, South Carolina.

Identified as smaller generators are the following:

- Energy Technology Engineering Center (ETEC) at Canoga Park, California
- Lawrence Berkeley Laboratory (LBL) at Berkeley, California
- Paducah Gaseous Diffusion Plant (PGDP) at Paducah, Kentucky
- Sandia National Laboratories (SNL) at Albuquerque, New Mexico
- University of Missouri at Columbia (U of Mo), Missouri
- West Valley Demonstration Project (WVDP) at West Valley, New York. The small amount of waste from this site originated from commercial reprocessing of spent nuclear fuel and so is not defense related.

The Draft WM PEIS analyzes the potential environmental impacts for managing approximately 65,000 cubic meters (2.3 million cubic feet) of retrievably stored CH-TRU waste and about 4,300 cubic meters (151,900 cubic feet) of retrievably stored RH-TRU waste. Approximately 95 percent of the existing CH-TRU waste and RH-TRU waste is stored at Hanford, INEL, LANL, ORR, RFETS, and SRS.

An additional 38,000 cubic meters (1.3 million cubic feet) of TRU waste was assumed to be generated over the next 20 years (excluding TRU waste that would result from environmental restoration activities), for a total of about 107,000 cubic meters (3.8 million cubic feet) of retrievably stored TRU waste. The inventory and annual generator rates for the Draft WM PEIS were obtained from the *Interim Mixed Waste Inventory Report* (DOE 1993) and the *Integrated Data Base for 1992* (DOE 1992). Table B-1 presents the waste volumes as used in Draft WM PEIS risk calculations; this table is the same as Draft WM PEIS Table 8.1-1. SEIS-II analyses differ slightly from the Draft WM PEIS regarding TRU waste volumes, years of generation, and the number of sites producing waste as discussed in Appendix A.

B.3.3 Waste Treatment

There are three alternative waste treatments considered in the Draft WM PEIS: treatment to the Waste Acceptance Criteria (WAC); shredding and using grout; and treatment to the RCRA Land Disposal Restrictions (LDR). Compliance with WAC is the minimum level of treatment required. The shred and grout treatment would be used to further stabilize the waste and reduce the rate of potential gas generation. LDRs are more restrictive than the WAC and would be required for disposal of mixed waste at WIPP, if WIPP's no migration variance petition is rejected, i.e., if the U.S. Environmental Protection Agency (EPA) determines that there is a reasonable degree of

Table B-1
Transuranic Waste Volumes (cubic meters)

Site[a]	CH-TRU Waste			RH-TRU Waste			Total
	Inventory	20-Year Projected Generation	Estimated Inventory + 20 Year Generation	Inventory	20-Year Projected Generation	Estimated Inventory + 20 Year Generation	
ANL-E	15	940	960	---	340	340	1,300
ETEC	0.02	---	0.02	---	---	---	0.02
Hanford	10,000	9,300	19,000	2,800	3,500	6,300	25,000
INEL	38,000	280	38,000	110	500	610	39,000
LANL	8,200	2,500	11,000	79	10	89	11,000
LBL	0.8	0.2	1	---	---	---	1
LLNL	200	1,500	1,700	---	---	---	1,700
Mound	274	1,200	1,500	---	---	---	1,500
NTS	610	---	610	---	---	---	610
ORR	670	360	1,000	1,300	360	1,700	2,700
PGDP	14	---	14	---	---	---	14
RFETS	1,500	4.800	6,200	---	---	---	6,200
SNL	1	---	1	---	---	---	1
SRS	5,400	12,000	17,000	---	---	---	17,000
U of Mo	---	2	2	---	---	---	2
WVDP	0.5	---	0.5	---	---	---	0.5
Total	**65,000**	**33,000**	**97,000**	**4,300**	**4,700**	**9,000**	**110,000**

[a] WIPP, the seventeenth site, does not currently have any TRU waste.

Note: Volume data are rounded from field estimates and columns and rows do not add. Waste volume projections contained in this and other Draft WM PEIS tables were based on 1994 or earlier data and may vary from the latest site estimates at the time of publication.

Sources: Draft WM PEIS, Table 8.1-1 [without modification]

certainty that waste will migrate past the unit boundary above health-based levels. For more information on these treatment technologies, see Chapter 2.

B.3.4 Alternatives

As stated above, the Draft WM PEIS was prepared to support decisions on where to treat and store TRU waste. To assist DOE in making decisions regarding the sites at which it should locate waste management facilities, the Draft WM PEIS considers four categories of alternatives for each waste type: the no action alternative, decentralized alternatives that would minimize the transportation of waste between sites, regionalized alternatives that would locate waste management facilities at several sites throughout the nation, and a centralized alternative that would locate large waste management facilities at only one site for CH-TRU waste and two sites for RH-TRU waste. For TRU waste, DOE considers more than one regionalized alternative in order to vary the number of sites having waste management facilities and the sites at which the facilities could be located. This variation among alternatives allows flexibility when considering the future configuration of waste management facilities. These TRU waste alternatives are summarized in the following subsections.

All Draft WM PEIS action alternatives discussed below assume that the waste would be shipped to WIPP for disposal.

B.3.4.1 Decentralized Alternative

Under the Draft WM PEIS Decentralized Alternative, DOE would, as needed, treat and package TRU waste to meet WAC. The treatment and packaging would occur at all sites. After treatment, CH-TRU waste would be shipped to the nearest one of the 10 sites with the larger amount of TRU waste for storage prior to disposal in WIPP.

B.3.4.2 Regionalized Alternatives

The Draft WM PEIS regionalized alternatives would consolidate TRU waste for treatment and storage prior to disposal. Three TRU waste regionalized alternatives are analyzed, with varying degrees of treatment at six and four sites, and storage at those sites prior to disposal in WIPP.

Regionalized 1

Under the Draft WM PEIS Regionalized 1 Alternative, CH-TRU waste would be shipped from the 10 smallest generators to the four sites with the largest volumes of TRU waste (Hanford, INEL, LANL, and SRS). In addition, RFETS would continue to treat its own waste, but would not receive waste from off site. RH-TRU waste would be shipped from ANL-E, INEL, and LANL to Hanford or ORR for treatment. At all six treatment sites, TRU waste would be treated using a shred and grout process (referred to in the Draft WM PEIS as the "reduce gas generation potential"). The six treatment sites proposed under this alternative have 95 percent of current and anticipated TRU waste inventories.

Regionalized 2

Under the Draft WM PEIS Regionalized 2 Alternative, DOE would use the same waste consolidation configuration as in Regionalized 1, except that the TRU waste would be treated to meet the LDRs.

Regionalized 3

Under the Draft WM PEIS Regionalized 3 Alternative, the consolidation of waste for treatment at four sites (Hanford, INEL, ORR, and SRS) where approximately 80 percent of TRU waste is already located or is expected to be generated is considered. CH-TRU waste would be treated at Hanford, INEL, and SRS; RH-TRU waste would be treated at Hanford and ORR. Under this alternative, TRU waste would be treated to meet the LDRs.

B.3.4.3 Centralized Alternative

Under the Draft WM PEIS Centralized Alternative, DOE would ship all CH-TRU waste to WIPP for treatment to meet the LDRs and for disposal. RH-TRU waste would be shipped to Hanford and ORR for treatment to meet the LDRs and eventually disposed of in WIPP.

B.3.4.4 No Action Alternative

Under the Draft WM PEIS No Action Alternative, DOE would continue to characterize, process, and package newly generated TRU waste based on the current WAC for storage at sites where existing or planned facilities are available. DOE would continue to store TRU waste in existing storage facilities for the duration of this analysis (20 years) and would not ship TRU waste for off-site storage or disposal. All sites are assumed to have adequate capabilities to package and store TRU waste generated in the future. Eleven sites have projected future TRU waste generation, including five sites generating both CH-TRU and RH-TRU waste. The Draft WM PEIS No Action Alternative does not assess the health risks, environmental impacts, or costs of removing TRU waste from retrievable storage and packaging it.

B.4 INCORPORATION OF DRAFT WM PEIS INTO SEIS-II ANALYSES

Draft WM PEIS analyses form the basis of the SEIS-II analysis of generator site impacts. These impacts, adjusted for different inventories and other analysis assumptions and combined with the SEIS-II analyses of impacts from waste disposal at WIPP and lag storage at the generator sites, present a comprehensive picture of the potential human health impacts complex-wide from management, treatment, and disposal of TRU waste.

The Draft WM PEIS examines potential impacts of management and treatment of the various waste types. Impact areas evaluated in the Draft WM PEIS for all of the waste types include human health risks, air quality, water resources, ecological resources, socioeconomics, land use, environmental justice, infrastructure, cultural resources, and cost.

The relevant portions of the Draft WM PEIS have been summarized and incorporated in SEIS-II. Where appropriate, the Draft WM PEIS impacts have been adjusted to reflect recent information such as revised estimates of future waste generation, cumulative impacts, and potential future activities at the sites. Life-cycle costs and transportation analyses have been reexamined and revised with the results presented in Chapter 5 and methods presented in Appendices D and E, respectively. Human health impacts from the Draft WM PEIS have also been adjusted to reflect waste inventory differences and other factors considered under the SEIS-II alternatives.

For routine operations involving treatment, health impacts in the Draft WM PEIS are evaluated for the off-site population, the on-site worker population not involved in treatment, and waste management workers directly involved in treatment activities. Impacts are quantified using two approaches: analysis of population health risk impacts and analysis of individual health risk impacts. Population impacts focus on the total number of people in each population who may experience adverse health impacts if a particular alternative were implemented.

B.5 USING HUMAN HEALTH IMPACTS FROM THE DRAFT WM PEIS

SEIS-II focuses on impacts from disposal of TRU waste. However, human health impacts from management and treatment of TRU waste at the generator sites, addressed in the Draft WM PEIS, may be a major contributor to the overall risk of disposing of TRU waste and preparing it for disposal.

Overall, in the Draft WM PEIS the numerically largest health risks result from alternatives where TRU waste is treated to meet the LDRs, (the Draft WM PEIS Regionalized 2, Regionalized 3, and

Centralized alternatives). These alternatives assume the use of thermal destruction of organic waste to meet the LDRs. This treatment method results in emissions of radionuclides that result in additional off-site cancer risks and increase the probability of cancer to the maximally exposed individual at SRS, LANL, and WIPP. Although postulated waste management worker fatalities primarily result from physical hazards, fatalities are lower when TRU waste is treated to planning-basis WAC or by a shred and grout process, than when TRU waste is treated to meet the LDRs.

Because of differences between the Draft WM PEIS and SEIS-II, it was necessary to adjust the impacts from the Draft WM PEIS before they could be used in SEIS-II. SEIS-II analyses use different TRU waste volumes and radionuclide inventories than those in the Draft WM PEIS. SEIS-II alternatives also differ from the Draft WM PEIS by having more years of waste generation and site operation, more sites producing waste, and, in some cases, the waste inventory and the manner of waste consolidation.

The following text describes how the potential human health impacts of TRU waste management and treatment reported in the Draft WM PEIS have been adjusted to account for differences between the Draft WM PEIS and SEIS-II.

Human health impacts adjusted from the Draft WM PEIS are those occurring as a result of routine operations and do not include accidents involving workers or members of the public. Therefore, only those impacts resulting from routine releases and exposure to radioactive material and hazardous chemicals, resulting in potential latent fatal cancers or cancer incidence, respectively, are adjusted. Effective adjustment factors were determined for each of the SEIS-II alternatives and Draft WM PEIS-dependent options within those alternatives for the Basic Inventory, Additional Inventory, and Total Inventory (detailed in Appendix A) for both CH-TRU and RH-TRU waste. Effective adjustment factors also were determined for populations and the maximally exposed individuals (MEI) for off-site populations and noninvolved workers (population and MEI). Categories of effective adjustment factors and their calculated values for CH-TRU and RH-TRU waste are shown in Tables B-2 and B-3, respectively. It should be noted that the RH-TRU waste adjustment factors for the population under the Basic Inventory and Total Inventory were constrained to be no less than 1 (SEIS-II impacts the same as Draft WM PEIS impacts) because of a lack of specific knowledge regarding the key radionuclides and their concentrations in RH-TRU waste. Additional information is provided below.

These adjustment factors were based on the Draft WM PEIS estimate of cancer incidence from exposure to radionuclides and chemicals, as presented for each site for RH-TRU and CH-TRU waste and each Draft WM PEIS alternative in Appendix D of the Draft WM PEIS. Because quantitative inventory information is not available for hazardous chemicals which may be present in TRU waste, adjustment factors were determined using radionuclide inventory and applied to hazardous chemicals.

Adjustment of the Draft WM PEIS human health impacts was a three-part process. These three steps are described below.

Step 1: Determine Site Adjustment Factors

The initial step was to determine site adjustment factors for the key contributing sites by considering differences between the Draft WM PEIS and SEIS-II. The differences considered

Table B-2
CH-TRU Waste Effective Adjustment Factors

SEIS-II Alternative (Draft WM PEIS Consolidation/Treatment Option)	Basic Inventory		Additional Inventory		Total Inventory	
	Off-Site Population & MEI and Noninvolved Worker Population & MEI	Involved Worker Population	Off-Site Population & MEI and Noninvolved Worker Population & MEI	Involved Worker Population	Off-Site Population & MEI and Noninvolved Worker Population & MEI	Involved Worker Population
Proposed Action (Decentralized)	1.5	2.8	N/A	N/A	N/A	N/A
Action Alternative 1 (Decentralized)	1.4	2.4	0.3	2.8	1.7	5.1
Action Alternative 2A (Regionalized 2)	1.2	3.4	0.2	3.8	1.4	7.2
Action Alternative 2B (Regionalized 3)	1	3.6	0.3	3.1	1	6.8
Action Alternative 2C (Centralized)	0.9	2.5	0.9	1.8	1.8	4.3
Action Alternative 3 (Regionalized 1)	2.3	3.2	0.4	3.6	2.6	6.7
No Action Alternative 1A (Regionalized 2)	1.2	3.4	0.2	3.8	1.4	7.2
No Action Alternative 1B (Regionalized 3)	0.7	3.3	0.3	3.7	1	7.0
No Action Alternative 2	3.0[a]	8.2[a]	N/A	N/A	N/A	N/A

[a] No Action Alternative 2 volume adjustments were based only on the newly generated waste volume.

N/A = Not Applicable

Table B-3
RH-TRU Waste Effective Adjustment Factors

SEIS-II Alternative (Draft WM PEIS Consolidation/Treatment Option)	Basic Inventory		Additional Inventory		Total Inventory	
	Off-Site Population & MEI and Noninvolved Worker Population & MEI	Involved Worker Population[a]	Off-Site Population & MEI and Noninvolved Worker Population & MEI	Involved Worker Population[a]	Off-Site Population & MEI and Noninvolved Worker Population & MEI	Involved Worker Population[a]
Proposed Action (Decentralized)	1 (0.2)	2.6	N/A	N/A	N/A	N/A
Action Alternative 1 (Decentralized)	1 (0.2)	2.6	7E-3	0.2	1 (0.2)	2.9
Action Alternative 2A, 2B, 2C (Regionalized 2, 3, Centralized)	1 (0.3)	1.9	1E-2	0.1	1 (0.4)	1.9
Action Alternative 3 (Regionalized 1)	1 (0.2)	2.7	7E-3	0.2	1 (0.2)	2.9
No Action Alternative 1A, 1B (Regionalized 2, 3)	1 (0.3)	1.9	1E-2	0.1	1 (0.4)	1.9
No Action Alternative 2 (No Action)	1 (0.3)[b]	8.3[b]	N/A	N/A	N/A	N/A

[a] Involved worker population RH-TRU waste adjustment factors consider waste volume changes only, not concentration changes. This is a conservative assumption that will tend to overestimate impacts to the involved worker population.
[b] No Action Alternative 2 volume adjustments were based only on the newly generated waste volume.

N/A = Not Applicable

included (1) the waste volume handled and treated (volume) and (2) changes in concentration of key radionuclides (concentration).

Site adjustment factors were determined for key sites using volume adjustment factors and concentration adjustment factors, as shown in the following equation:

$$\left(\left[SF_{site} = \frac{V_{SEIS}}{V_{WM\ PEIS}} \times \frac{C_{SEIS}}{C_{WM\ PEIS}} \right]_{keysite} \right)_{\text{alternative, subalternative}} \qquad \text{(Equation B-1)}$$

where

SF_{site} = site adjustment factor for key contributing sites

V_{SEIS} = site waste volume in SEIS-II

$V_{WM\ PEIS}$ = site waste volume in the Draft WM PEIS

C_{SEIS} = site key radionuclide concentration in SEIS-II

$C_{WM\ PEIS}$ = site key radionuclide concentration in the Draft WM PEIS

The calculation was done for each of the key contributing sites for each of the SEIS-II alternatives and for each applicable subalternative.

Key contributing sites were determined by ranking the sites by cancer incidence risk for each alternative. The sites with the largest risk were then selected until a contribution of at least 90 percent of the total cancer incidence risk as reported in the Draft WM PEIS was reached.

The key sites that resulted from this process differed among alternatives. However, each alternative's key sites for CH-TRU waste included one or more of the following: SRS, LANL, RFETS, Hanford, WIPP, or INEL. Those for RH-TRU waste included ORNL and Hanford, and in several cases for involved workers INEL, as well. No other sites were key contributors. For each alternative, the sum of the risk from the key contributing sites was between 92 and 100 percent of that presented in the Draft WM PEIS.

Volume information for the SEIS-II factors was taken from the "Pre-Treatment Consolidated Volume" columns of Tables 3-1 through 3-16 of Chapter 3 in this document. When applicable to the respective alternative, the calculations were done for each of three SEIS-II inventories: the Basic Inventory, the Additional Inventory, and the Total Inventory (for more information on these inventories, see Chapter 2 and Appendix A).

The Draft WM PEIS TRU waste volumes used to determine site adjustment factors were those presented in Table B-1. These waste volumes are also presented in Table 8.1-1 of the Draft WM PEIS.

Key radionuclides are those defined in Appendix D of the Draft WM PEIS as the single radionuclide contributing the highest risk of cancer fatality at each site under each alternative. Key radionuclides are identified in Appendix D of the Draft WM PEIS. Those in CH-TRU waste

contributing the highest risk to off-site populations are listed on Draft WM PEIS Table D.3.4-18, and those contributing the highest risk to the involved workers are stated at the bottom of page D-202. For RH-TRU waste, those contributing the highest risk to off-site populations are listed on Draft WM PEIS Table D.3.4-34, and those contributing the highest risk to involved workers are presented on page D-221.

Once these key radionuclides were identified, radionuclide concentration information for the SEIS-II factors was calculated using the radionuclide inventory data shown in Appendix A of this document, and the volume information from Chapter 3. Concentrations were determined by dividing the total activity per year of a particular radionuclide by the total annual volume in cubic meters per year.

The concentrations of the Draft WM PEIS key radionuclides at the various sites were taken from the tables in Appendix B of *Transuranic Waste Inventory, Characteristics, Generation, and Facility Assessment for Treatment, Storage, and Disposal Alternatives Considered in the U.S. Department of Energy Waste Management Programmatic Environmental Impact Statement* (ANL 1995). The tables used for Draft WM PEIS CH-TRU waste radionuclide concentrations were as follows (for an explanation of the SEIS-II alternatives, see Chapter 3 of this document):

- Table B-1 was used for No Action Alternative 2
- Table B-2 was used for the Proposed Action and Action Alternative 1
- Table B-3 was used for Action Alternative 3
- Table B-4 was used for Action Alternative 2A and No Action Alternative 1A
- Table B-5 was used for Action Alternative 2B and No Action Alternative 1B
- Table B-6 was used for Action Alternative 2C

The tables used for Draft WM PEIS RH-TRU waste radionuclide concentrations were as follows:

- Table B-7 was used for No Action Alternative 2
- Table B-8 was used for the Proposed Action and Action Alternative 1
- Table B-9 was used for Action Alternative 3
- Table B-10 was used for all subalternatives of Action Alternative 2 and No Action Alternative 1

The exception to this approach was for worker impacts from RH-TRU waste, where the key radionuclide concentration ratio was defaulted to 1 for all alternatives and options. This was done for two reasons. First, only about 15 percent of the estimated RH-TRU waste volume in the *Transuranic Waste Baseline Inventory Report* (BIR-2) (DOE 1995b) has radionuclide inventory information associated with it. Secondly, the key radionuclides identified in the Draft WM PEIS (principally, uranium-233 and uranium-236) did not appear to be present in sufficient concentrations in the SEIS-II inventory to justify being key radionuclides. Therefore, adjustment

factors for worker exposures to RH-TRU waste reflected only waste volume changes, which, except for the Additional Inventory, are always greater than 1 (SEIS-II volumes are greater than Draft WM PEIS volumes).

Step 2: Adjust Site-Specific Cancer Incidence

Using the site adjustment factors, the site-specific cancer incidence risk values presented in Draft WM PEIS Appendix D (Tables D.3.4-13 to D.3.4-17 for CH-TRU waste and Tables D.3.4-31 to D.3.4-33 for RH-TRU waste) were adjusted as shown in Equation B-2. Cancer incidence was selected as the basis for adjustment because incidence values include impacts from both radionuclide and hazardous chemical exposure. Use of cancer incidence for adjusting radionuclide impacts is conservative because not all radiation-induced cancers are fatal while radiation exposure impacts are reported as latent cancer fatalities (LCFs).

Therefore, for each key site, the adjustment factor was multiplied by the site's cancer incidence risk value in the Draft WM PEIS Appendix D tables listed above. Also, since only the key sites were considered and they sometimes contributed less than 100 percent of the total cancer incidence risk, an adjustment for key site contribution to risk was necessary, shown in the denominator of Equation B-2:

$$\left[R\,(\mathrm{adj})_{\mathrm{WM\ PEIS}} = \frac{\sum \left(SF_{\mathrm{site}} \times R_{\mathrm{cancer\ incidence}} \right)_{\mathrm{keysites}}}{\left(\dfrac{\%_{R,\,keysites}}{100\%_{R}} \right)} \right]_{\mathrm{alternative,\ subalternative}} \qquad \text{(Equation B-2)}$$

where

$R\,(\mathrm{adj})_{\mathrm{WM\ PEIS}}$ = adjusted cancer incidence risk from the Draft WM PEIS value

$R_{\mathrm{cancer\ incidence}}$ = cancer incidence risk presented in the Draft WM PEIS

$\%_{\mathrm{R,\ keysites}}$ = percent contribution of the key sites to the total Draft WM PEIS cancer incidence risk value

$100\%_{\mathrm{R}}$ = 1.0, expressed as a percent, as a divisor for $\%_{\mathrm{R,\ keysites}}$

Step 3: Determine Effective Adjustment Factor

The effective Draft WM PEIS adjustment factor was then determined by dividing the adjusted Draft WM PEIS cancer incidence risk values by the corresponding Draft WM PEIS estimated cancer incidence risk as shown in Equation B-3. These are the values that are presented in Tables B-2 and B-3:

$$\left[S_{\mathrm{WM\ PEIS,\ eff}} = \frac{R\,(\mathrm{adj})_{\mathrm{WM\ PEIS}}}{R_{\mathrm{WM\ PEIS}}} \right]_{\mathrm{alternative,\ subalternative}} \qquad \text{(Equation B-3)}$$

where

$S_{WM\ PEIS,eff}$ = the effective adjustment factor used to adjust the Draft WM PEIS human health impacts due to changes in waste volume and key radionuclide concentrations in SEIS-II

$R_{WM\ PEIS}$ = the Draft WM PEIS program-wide risk value.

Finally, these effective Draft WM PEIS adjustment factors were multiplied by the program-wide cancer incidence risk values presented in Appendix D (Tables D.3.4-7 to D.3.4-11 for CH-TRU and Tables D.3.4-27 to 29 for RH-TRU).

Example Calculation

Following is an example calculation that shows how the effective adjustment factor was determined for the population and noninvolved worker (population and MEI) impacts from CH-TRU waste under the Proposed Action.

Step 1: Determining Site Adjustment Factors for CH-TRU waste under Proposed Action for Population and Uninvolved Workers

First, the site adjustment factors were determined for four key contributing sites: SRS, LANL, RFETS, and Hanford. Key contributing sites were identified by analyzing the cancer incidence data presented as part of Step 2. These sites contribute 92 percent of the total cancer incidence risk determined in the Draft WM PEIS. Hanford was included as a key potential contributor because its large site-adjustment factor (10.6) indicated that it might provide an important contribution (Table B-4).

Table B-4
Step 1 Calculation Results

Site	Waste Volume Adjustment Factor $\frac{V_{SEIS}}{V_{WM\ PEIS}}$	Key Radionuclide Concentration Adjustment Factor $\frac{C_{SEIS}}{C_{WM\ PEIS}}$	Site Adjustment Factor SF_{site}
SRS	0.7	71.0/58.2 = 1.2 (Pu-238)	0.9
LANL	1.9	1.1/17.3 = 0.07 (Am-241)	0.1
RFETS	1.8	19.6/3.2 = 6.2 (Am-241)	11.8
Hanford	3.0	7.8/2.2 = 3.5 (Pu-238)	10.6

Step 2: Determining the Adjusted Draft WM PEIS Risk

Then, the adjusted Draft WM PEIS cancer incidence risk was determined, as shown. Note how the contributions from the various sites change from the Draft WM PEIS due to differences in the waste volumes and the concentration of the key radionuclide between SEIS-II and the Draft WM PEIS inventories. Contributions from RFETS and Hanford increase substantially for SEIS-II over Draft WM PEIS as a result of the high site adjustment factors determined in Step 1 (Table B-5).

Table B-5
Step 2 Calculation Results

Key Site Contributors, Decentralized Alternative, Off-Site Population	$R_{cancer\ incidence}$ Site Contribution (Draft WM PEIS Tables D.3.4-3 and D.3.4-13)	$\%_{R,\ keysites}$	Sf_{site} x $R_{cancer\ incidence}$ (Adjusted Percent Contribution)	Adjusted Draft WM PEIS Risk, $R\ (adj)_{WM\ PEIS}$
Total	4.2E-04	---	---	6.2E-04
SRS	1.7E-04 (40.5%)	92%	1.5E-04 (25.9%)	---
LANL	1.8E-04 (42.9%)	---	2.5E-05 (4.4%)	---
RFETS	3.2E-05 (7.6%)	---	3.5E-04 (60.8%)	---
Hanford	4.8E-06 (1.1%)	---	5.1E-05 (9.0%)	---

Step 3: Example of Determining the Effective Adjustment Factor

Finally, the effective adjustment factor is determined, by dividing the adjusted Draft WM PEIS cancer incidence risk determined in Step 2 by the Draft WM PEIS cancer incidence risk from Appendix D. This adjustment factor is then multiplied by the appropriate Draft WM PEIS Program-Wide Risk value to determine the adjusted results of population impacts under the Proposed Action (Table B-6).

Table B-6
Step 3 Calculation Results

$R_{(adj),\ WM\ PEIS}$ /$R_{(WM\ PEIS)}$	$S_{WM\ PEIS,\ eff}$
6.2 E-04 /4.2 E-04	1.5

Summary of Results. Adjustment of the Draft WM PEIS human health impacts is a direct reflection of the effective adjustment factors presented in Tables B-2 and B-3. Impacts are principally noted to the off-site population and to waste management workers. LCFs from exposure to radionuclides may be expected in the off-site population under Action Alternative 2 and No Action Alternatives 1A and 1B. There is an expectation of up to five LCFs for the total inventory under No Action Alternative 1A. LCFs may also be expected in waste management workers under all alternatives and options except No Action Alternative 2. There is a mathematical expectation of 4 to 5 LCFs from exposure to radionuclides under Action Alternatives 2A and 2B, Action Alternative 3, and No Action Alternatives 1A and 1B. No impacts are expected to any of the analyzed groups from exposure to hazardous chemicals, and there is no expectation of LCFs in the noninvolved worker population, the noninvolved worker MEI, or the off-site population MEI. For RH-TRU waste treatment and management, there is no expectation of cancer incidence or fatality from exposure to hazardous chemicals or radionuclides.

The adjusted human health impacts from DOE site treatment and management of CH-TRU waste are presented in Tables B-7 through B-9. Human health impacts from RH-TRU waste are presented in Tables B-10 through B-12.

Table B-7
Human Health Impacts Associated with Treatment of CH-TRU Waste from Radionuclides and Chemicals in the Basic Inventory

Receptor	Draft WM PEIS						SEIS-II								
	No Action (Table D.3.4-6)	Decent. (Table D.3.4-7)	Reg. 1 (Table D.3.4-8)	Reg. 2 (Table D.3.4-9)	Reg. 3 (Table D.3.4-10)	Cent. (Table D.3.4-11)	Proposed Action	Action Alternative 1	Action Alternative 2			Action Alternative 3	No Action Alternative 1		No Action Alternative 2
									2A	2B	2C		1A	1B	
Radionuclides															
NI Worker Population[a]															
Dose	4.2E-3	2.3E-2	3.2E-2	6.9E+2	5.8E+2	9.9E+1	3.5E-2	3.2E-2	8.3E+2	5.8E+2	8.9E+1	7.4E-2	8.3E+2	4.1E+2	1.3E-2
LCF	2.1E-6	1.1E-5	1.6E-5	3.4E-1	2.9E-1	5.0E-2	1.7E-5	1.5E-5	4.1E-1	2.9E-1	4.5E-2	3.7E-5	4.1E-1	2.0E-1	6.3E-6
NI Worker MEI[b]															
Dose	2.6E-6	9.5E-6	1.5E-5	4.9E-1	4.9E-1	3.8E-1	1.4E-5	1.3E-5	5.9E-1	4.9E-1	3.4E-1	3.5E-5	5.9E-1	3.4E-1	7.8E-6
LCF	1.3E-9	4.8E-9	7.7E-9	2.4E-4	2.4E-4	1.9E-4	7.2E-9	6.7E-9	2.9E-4	2.4E-4	1.7E-4	1.8E-8	2.9E-4	1.7E-4	3.9E-9
Off-site Population															
Dose	4.6E-2	2.4E-1	3.4E-1	6.7E+3	5.2E+3	1.2E+3	3.6E-1	3.4E-1	8.0E+3	5.2E+3	1.1E+3	7.8E-1	8.0E+3	3.6E+3	1.4E-1
LCF	2.3E-5	1.2E-4	1.7E-4	3.3E+0	2.6E+0	6.1E-1	1.8E-4	1.7E-4	4.0E+0	2.6E+0	5.5E-1	3.9E-4	4.0E+0	1.8E+0	6.9E-5
Off-site MEI															
Dose	8.7E-7	1.1E-5	1.4E-5	1.3E-1	4.8E-2	3.2E-1	1.7E-5	1.5E-5	1.6E-1	4.8E-2	2.9E-1	3.2E-5	1.6E-1	3.4E-2	2.6E-6
LCF	4.4E-10	5.7E-9	6.9E-9	6.7E-5	2.4E-5	1.6E-4	8.6E-9	8.0E-9	8.0E-5	2.4E-5	1.4E-4	1.6E-8	8.0E-5	1.7E-5	1.3E-9
Involved Workers[c]															
Dose	2.4E+1	1.5E+3	1.6E+3	1.5E+3	1.6E+3	1.7E+3	4.2E+3	3.6E+3	5.1E+3	5.8E+3	4.3E+3	5.1E+3	5.1E+3	5.3E+3	2.0E+2
LCF	9.6E-3	6.0E-1	6.3E-1	6.1E-1	6.6E-1	6.8E-1	1.7E+0	1.4E+0	2.1E+0	2.4E+0	1.7E+0	2.0E+0	2.1E+0	2.2E+0	7.9E-2
Chemicals															
NI Worker Population															
Cancer Incidence	3.5E-9	3.4E-8	5.8E-8	5.6E-8	5.7E-8	6.6E-8	5.1E-8	4.8E-8	6.7E-8	5.7E-8	5.9E-8	1.3E-7	6.7E-8	4.0E-8	1.1E-8
NI Worker MEI															
Cancer Incidence	9.9E-13	8.9E-12	1.5E-11	1.5E-11	1.5E-11	1.5E-11	1.3E-11	1.2E-11	1.8E-11	1.5E-11	1.4E-11	3.5E-11	1.8E-11	1.1E-11	3.0E-12
Hazard Index	2.7E-10	1.4E-9	2.5E-9	1.3E-7	1.3E-7	4.6E-7	2.1E-9	2.0E-9	1.6E-7	1.3E-7	4.1E-7	5.8E-9	1.6E-7	9.1E-8	8.1E-10
Off-site Population															
Cancer Incidence	1.4E-8	1.3E-7	2.3E-7	2.2E-7	2.2E-7	2.3E-7	2.0E-7	1.8E-7	2.6E-7	2.2E-7	2.1E-7	5.3E-7	2.6E-7	1.5E-7	4.2E-8
Off-site MEI															
Cancer Incidence	3.1E-13	2.8E-12	4.8E-12	4.8E-12	4.8E-12	4.8E-12	4.2E-12	3.9E-12	5.8E-12	4.8E-12	4.3E-12	1.1E-11	5.8E-12	3.4E-12	9.3E-13
Hazard Index	2.6E-11	1.5E-10	2.2E-10	1.1E-8	3.0E-9	7.6E-8	2.3E-10	2.1E-10	1.3E-8	3.0E-9	6.8E-8	5.1E-10	1.3E-8	2.1E-9	7.8E-11
Involved Workers															
Cancer Incidence	3.8E-7	1.0E-5	2.0E-5	2.5E-5	3.6E-5	8.6E-5	2.8E-5	2.4E-5	8.5E-5	1.3E-4	2.2E-4	6.4E-5	8.5E-5	1.2E-4	3.1E-6
Exposed Index	2.6E-6	3.1E-5	3.1E-5	8.6E-4	8.6E-4	1.1E-3	8.7E-5	7.4E-5	2.9E-3	3.1E-3	2.8E-3	9.9E-5	2.9E-3	2.8E-3	2.1E-5

[a] NI Worker Population dose is in person-rem
[b] NI Worker MEI dose is in rem
[c] Involved Worker Dose is in full time equivalent-rem

NI Worker = Noninvolved Worker
MEI = Maximally Exposed Individual
LCF = Latent Cancer Fatalities

Table B-8
Human Health Impacts Associated with Treatment of CH-TRU Waste from Radionuclides and Chemicals in the Additional Inventory

Receptor	Draft WM PEIS					SEIS-II								
	Decent. (Table D.3.4-7)	Reg. 1 (Table D.3.4-8)	Reg. 2 (Table D.3.4-9)	Reg. 3 (Table D.3.4-10)	Cent. (Table D.3.4-11)	Proposed Action	Action Alternative 1	Action Alternative 2			Action Alternative 3	No Action Alternative 1		No Action Alternative 2
								2A	2B	2C		1A	1B	
Radionuclides														
NI Worker Population[a]														
Dose	2.3E-2	3.2E-2	6.9E+2	5.8E+2	9.9E+1	N/A	6.9E-3	1.4E+2	1.7E+2	8.9E+1	1.3E-2	1.4E+2	1.7E+2	N/A
LCF	1.1E-5	1.6E-5	3.4E-1	2.9E-1	5.0E-2	N/A	3.3E-6	6.8E-2	8.7E-2	4.5E-2	6.4E-6	6.8E-2	8.7E-2	N/A
NI Worker MEI[b]														
Dose	9.5E-6	1.5E-5	4.9E-1	4.9E-1	3.8E-1	N/A	2.9E-6	9.8E-2	1.5E-1	3.4E-1	6.0E-6	9.8E-2	1.5E-1	N/A
LCF	4.8E-9	7.7E-9	2.4E-4	2.4E-4	1.9E-4	N/A	1.4E-9	4.8E-5	7.2E-5	1.7E-4	3.1E-9	4.8E-5	7.2E-5	N/A
Off-site Population														
Dose	2.4E-1	3.4E-1	6.7E+3	5.2E+3	1.2E+3	N/A	7.2E-2	1.3E+3	1.6E+3	1.1E+3	1.4E-1	1.3E+3	1.6E+3	N/A
LCF	1.2E-4	1.7E-4	3.3E+0	2.6E+0	6.1E-1	N/A	3.6E-5	6.6E-1	7.8E-1	5.5E-1	6.8E-5	6.6E-1	7.8E-1	N/A
Off-site MEI														
Dose	1.1E-5	1.4E-5	1.3E-1	4.8E-2	3.2E-1	N/A	3.3E-6	2.6E-2	1.4E-2	2.9E-1	5.6E-6	2.6E-2	1.4E-2	N/A
LCF	5.7E-9	6.9E-9	6.7E-5	2.4E-5	1.6E-4	N/A	1.7E-9	1.3E-5	7.2E-6	1.4E-4	2.8E-9	1.3E-5	7.2E-6	N/A
Involved Workers[c]														
Dose	1.5E+3	1.6E+3	1.5E+3	1.6E+3	1.7E+3	N/A	4.2E+3	5.7E+3	5.0E+3	3.1E+3	5.8E+3	5.7E+3	5.9E+3	N/A
LCF	6.0E-1	6.3E-1	6.1E-1	6.6E-1	6.8E-1	N/A	1.7E+0	2.3E+0	2.0E+0	1.2E+0	2.3E+0	2.3E+0	2.4E+0	N/A
Chemicals														
NI Worker Population														
Cancer Incidence	3.4E-8	5.8E-8	5.6E-8	5.7E-8	6.6E-8	N/A	1.0E-8	1.1E-8	1.7E-8	5.9E-8	2.3E-8	1.1E-8	1.7E-8	N/A
NI Worker MEI														
Cancer Incidence	8.9E-12	1.5E-11	1.5E-11	1.5E-11	1.5E-11	N/A	2.7E-12	3.0E-12	4.5E-12	1.4E-11	6.0E-12	3.0E-12	4.5E-12	N/A
Hazard Index	1.4E-9	2.5E-9	1.3E-7	1.3E-7	4.6E-7	N/A	4.2E-10	2.6E-8	3.9E-8	4.1E-7	1.0E-9	2.6E-8	3.9E-8	N/A
Off-site Population														
Cancer Incidence	1.3E-7	2.3E-7	2.2E-7	2.2E-7	2.3E-7	N/A	3.9E-8	4.4E-8	6.6E-8	2.1E-7	9.2E-8	4.4E-8	6.6E-8	N/A
Off-site MEI														
Cancer Incidence	2.8E-12	4.8E-12	4.8E-12	4.8E-12	4.8E-12	N/A	8.4E-13	9.6E-13	1.4E-12	4.3E-12	1.9E-12	9.6E-13	1.4E-12	N/A
Hazard Index	1.5E-10	2.2E-10	1.1E-8	3.0E-9	7.6E-8	N/A	4.5E-11	2.2E-9	9.0E-10	6.8E-8	8.8E-11	2.2E-9	9.0E-10	N/A
Involved Workers														
Cancer Incidence	1.0E-5	2.0E-5	2.5E-5	3.6E-5	8.6E-5	N/A	2.8E-5	9.5E-5	1.1E-4	1.5E-4	7.2E-5	9.5E-5	1.3E-4	N/A
Exposure Index	3.1E-5	3.1E-5	8.6E-4	8.6E-4	1.1E-3	N/A	8.7E-5	3.3E-3	2.7E-3	2.0E-3	1.1E-4	3.3E-3	3.2E-3	N/A

[a] NI Worker Population dose is in person-rem
[b] NI Worker MEI dose is in rem
[c] Involved Worker Dose is in full time equivalent-rem

NI Worker = Noninvolved Worker
MEI = Maximally Exposed Individual
LCF = Latent Cancer Fatalities
N/A = Not Applicable

Table B-9
Human Health Impacts Associated with Treatment of CH-TRU Waste from Radionuclides and Chemicals in the Total Inventory

Receptor	Draft WM PEIS					SEIS-II								
	Decent. (Table D.3.4-7)	Reg. 1 (Table D.3.4-8)	Reg. 2 (Table D.3.4-9)	Reg. 3 (Table D.3.4-10)	Cent. (Table D.3.4-11)	Proposed Action	Action Alternative 1	Action Alternative 2			Action Alternative 3	No Action Alternative 1		No Action Alternative 2
								2A	2B	2C		1A	1B	
Radionuclides														
NI Worker Population[a]														
Dose	2.3E-2	3.2E-2	6.9E+2	5.8E+2	9.9E+1	N/A	3.9E-2	9.7E+2	5.8E+2	1.8E+2	8.3E-2	9.7E+2	5.8E+2	N/A
LCF	1.1E-5	1.6E-5	3.4E-1	2.9E-1	5.0E-2	N/A	1.9E-5	4.8E-1	2.9E-1	9.0E-2	4.2E-5	4.8E-1	2.9E-1	N/A
NI Worker MEI[b]														
Dose	9.5E-6	1.5E-5	4.9E-1	4.9E-1	3.8E-1	N/A	1.6E-5	6.9E-1	4.9E-1	6.8E-1	3.9E-5	6.9E-1	4.9E-1	N/A
LCF	4.8E-9	7.7E-9	2.4E-4	2.4E-4	1.9E-4	N/A	8.2E-9	3.4E-4	2.4E-4	3.4E-4	2.0E-8	3.4E-4	2.4E-4	N/A
Off-site Population														
Dose	2.4E-1	3.4E-1	6.7E+3	5.2E+3	1.2E+3	N/A	4.1E-1	9.4E+3	5.2E+3	2.2E+3	8.8E-1	9.4E+3	5.2E+3	N/A
LCF	1.2E-4	1.7E-4	3.3E+0	2.6E+0	6.1E-1	N/A	2.0E-4	4.6E+0	2.6E+0	1.1E+0	4.4E-4	4.6E+0	2.6E+0	N/A
Off-site MEI														
Dose	1.1E-5	1.4E-5	1.3E-1	4.8E-2	3.2E-1	N/A	1.9E-5	1.8E-1	4.8E-2	5.8E-1	3.6E-5	1.8E-1	4.8E-2	N/A
MEI	5.7E-9	6.9E-9	6.7E-5	2.4E-5	1.6E-4	N/A	9.7E-9	9.4E-5	2.4E-5	2.9E-4	1.8E-8	9.4E-5	2.4E-5	N/A
Involved Workers[c]														
Dose	1.5E+3	1.6E+3	1.5E+3	1.6E+3	1.7E+3	N/A	7.7E+3	1.1E+4	1.1E+4	7.3E+3	1.1E+4	1.1E+4	1.1E+4	N/A
LCF	6.0E-1	6.3E-1	6.1E-1	6.6E-1	6.8E-1	N/A	3.1E+0	4.4E+0	4.5E+0	2.9E+0	4.2E+0	4.4E+0	4.6E+0	N/A
Chemicals														
NI Worker Population														
Cancer Incidence	3.4E-8	5.8E-8	5.6E-8	5.7E-8	6.6E-8	N/A	5.8E-8	7.8E-8	5.7E-8	1.2E-7	1.5E-7	7.8E-8	5.7E-8	N/A
NI Worker MEI														
Cancer Incidence	8.9E-12	1.5E-11	1.5E-11	1.5E-11	1.5E-11	N/A	1.5E-11	2.1E-11	1.5E-11	2.7E-11	3.9E-11	2.1E-11	1.5E-11	N/A
Hazard Index	1.4E-9	2.5E-9	1.3E-7	1.3E-7	4.6E-7	N/A	2.4E-9	1.8E-7	1.3E-7	8.3E-7	6.5E-9	1.8E-7	1.3E-7	N/A
Off-site Population														
Cancer Incidence	1.3E-7	2.3E-7	2.2E-7	2.2E-7	2.3E-7	N/A	2.2E-7	3.1E-7	2.2E-7	4.1E-7	6.0E-7	3.1E-7	2.2E-7	N/A
Off-site MEI														
Cancer Incidence	2.8E-12	4.8E-12	4.8E-12	4.8E-12	4.8E-12	N/A	4.8E-12	6.7E-12	4.8E-12	8.6E-12	1.2E-11	6.7E-12	4.8E-12	N/A
Hazard Index	1.5E-10	2.2E-10	1.1E-8	3.0E-9	7.6E-8	N/A	2.6E-10	1.5E-8	3.0E-9	1.4E-7	5.7E-10	1.5E-8	3.0E-9	N/A
Involved Workers														
Cancer Incidence	1.0E-5	2.0E-5	2.5E-5	3.6E-5	8.6E-5	N/A	5.1E-5	1.8E-4	2.4E-4	3.7E-4	1.3E-4	1.8E-4	2.5E-4	N/A
Exposure Index	3.1E-5	3.1E-5	8.6E-4	8.6E-4	1.1E-3	N/A	1.6E-4	6.2E-3	5.8E-3	4.7E-3	2.1E-4	6.2E-3	6.0E-3	N/A

[a] NI Worker Population dose is in person-rem
[b] NI Worker MEI dose is in rem
[c] Involved Worker Dose is in full time equivalent-rem

NI Worker = Noninvolved Worker
MEI = Maximally Exposed Individual
LCF = Latent Cancer Fatalities
N/A = Not Applicable

Table B-10
Human Health Impacts Associated with Treatment of RH-TRU Waste from Radionuclides and Chemicals in the Basic Inventory

Receptor	Draft WM PEIS				SEIS-II					
	No Action (Draft WM PEIS Table D.3.4-26)	Decentralized (Draft WM PEIS Table D.3.4-27)	Regionalized 1 (Draft WM PEIS Table D.3.4-28)	Regionalized 2, 3, Centralized (Draft WM PEIS Table D.3.4-29)	Proposed Action	Action Alternative 1	Action Alternative 2	Action Alternative 3	No Action Alternative 1	No Action Alternative 2
Radionuclides										
NI Worker Population[a]										
Dose	7.4E-5	4.5E-4	4.8E-4	3.6E+0	4.5E-4	4.5E-4	3.6E+0	4.8E-4	3.6E+0	7.4E-5
LCF	3.7E-8	2.3E-7	2.4E-7	1.8E-3	2.3E-7	2.3E-7	1.8E-3	2.4E-7	1.8E-3	3.7E-8
NI Worker MEI[b]										
Dose	1.2E-7	6.7E-7	7.0E-7	2.8E-3	6.7E-7	6.7E-7	2.8E-3	7.0E-7	2.8E-3	1.2E-7
LCF	5.8E-11	3.4E-10	3.5E-10	1.4E-6	3.4E-10	3.4E-10	1.4E-6	3.5E-10	1.4E-6	5.8E-11
Off-site Population										
Dose	1.8E-3	1.1E-2	1.1E-2	1.0E+2	1.1E-2	1.1E-2	1.0E+2	1.1E-2	1.0E+2	1.8E-3
LCF	8.8E-7	5.3E-6	5.6E-6	5.2E-2	5.3E-6	5.3E-6	5.2E-2	5.6E-6	5.2E-2	8.8E-7
Off-site MEI										
Dose	3.0E-8	1.8E-7	1.9E-7	2.8E-3	1.8E-7	1.8E-7	2.8E-3	1.9E-7	2.8E-3	3.0E-8
LCF	1.5E-11	8.8E-11	9.3E-11	1.4E-6	8.8E-11	8.8E-11	1.4E-6	9.3E-11	1.4E-6	1.5E-11
Involved Workers[c]										
Dose	4.2E-1	1.2E+1	1.3E+1	2.3E+2	3.1E+1	3.1E+1	4.4E+2	3.5E+1	4.4E+2	3.5E+0
LCF	1.7E-4	4.9E-3	5.1E-3	9.3E-2	1.3E-2	1.3E-2	1.8E-1	1.4E-2	1.8E-1	1.4E-3
Chemicals										
NI Worker Population										
Cancer Incidence	2.6E-9	5.2E-8	5.2E-8	3.7E-8	5.2E-8	5.2E-8	3.7E-8	5.2E-8	3.7E-8	2.6E-9
NI Worker MEI										
Cancer Incidence	2.5E-12	5.0E-11	5.0E-11	3.5E-11	5.0E-11	5.0E-11	3.5E-11	5.0E-11	3.5E-11	2.5E-12
Hazard Index	2.0E-11	8.0E-10	8.0E-10	1.2E-8	8.0E-10	8.0E-10	1.2E-8	8.0E-10	1.2E-8	2.0E-11
Off-site Population										
Cancer Incidence	8.1E-9	1.6E-7	1.6E-7	1.1E-7	1.6E-7	1.6E-7	1.1E-7	1.6E-7	1.1E-7	8.1E-9
Off-site MEI										
Cancer Incidence	4.0E-13	8.1E-12	8.1E-12	5.7E-12	8.1E-12	8.1E-12	5.7E-12	8.1E-12	5.7E-12	4.0E-13
Hazard Index	3.3E-12	1.3E-10	1.3E-10	1.9E-9	1.3E-10	1.3E-10	1.9E-9	1.3E-10	1.9E-9	3.3E-12
Involved Workers										
Cancer Incidence	8.7E-8	3.0E-6	3.4E-6	5.2E-6	7.8E-6	7.8E-6	9.9E-6	9.2E-6	9.9E-6	7.2E-7
Exposure Index	3.0E-6	3.0E-5	3.0E-5	3.0E-5	7.8E-5	7.8E-5	5.7E-5	8.1E-5	5.7E-5	2.5E-5

[a] NI Worker Population dose is in person-rem
[b] NI Worker MEI dose is in rem
[c] Involved Worker Dose is in full time equivalent-rem

NI Worker = Noninvolved Worker
MEI = Maximally Exposed Individual
LCF = Latent Cancer Fatalities

Table B-11
Human Health Impacts Associated with Treatment of RH-TRU Waste from Radionuclides and Chemicals in the Additional Inventory

Receptor	Draft WM PEIS			SEIS-II					
	Decentralized (Draft WM PEIS Table D.3.4-27)	Regionalized 1 (Draft WM PEIS Table D.3.4-28)	Regionalized 2, 3, Centralized (Draft WM PEIS Table D.3.4-29)	Proposed Action	Action Alternative 1	Action Alternative 2	Action Alternative 3	No Action Alternative 1	No Action Alternative 2
Radionuclides									
NI Worker Population[a]									
Dose	4.5E-4	4.8E-4	3.6E+0	N/A	3.2E-6	3.6E-2	3.4E-6	3.6E-2	N/A
LCF	2.3E-7	2.4E-7	1.8E-3	N/A	1.6E-9	1.8E-5	1.7E-9	1.8E-5	N/A
NI Worker MEI[b]									
Dose	6.7E-7	7.0E-7	2.8E-3	N/A	4.7E-9	2.8E-5	4.9E-9	2.8E-5	N/A
LCF	3.4E-10	3.5E-10	1.4E-6	N/A	2.4E-12	1.4E-8	2.5E-12	1.4E-8	N/A
Off-site Population									
Dose	1.1E-2	1.1E-2	1.0E+2	N/A	7.7E-5	1.0E+0	7.7E-5	1.0E+0	N/A
LCF	5.3E-6	5.6E-6	5.2E-2	N/A	3.7E-8	5.2E-4	3.9E-8	5.2E-4	N/A
Off-site MEI									
Dose	1.8E-7	1.9E-7	2.8E-3	N/A	1.3E-9	2.8E-5	1.3E-9	2.8E-5	N/A
LCF	8.8E-11	9.3E-11	1.4E-6	N/A	6.2E-13	1.4E-8	6.5E-13	1.4E-8	N/A
Involved Workers[c]									
Dose	1.2E+1	1.3E+1	2.3E+2	N/A	2.4E+0	2.3E+1	2.6E+0	2.3E+1	N/A
LCF	4.9E-3	5.1E-3	9.3E-2	N/A	9.8E-4	9.3E-3	1.0E-3	9.3E-3	N/A
Chemicals									
NI Worker Population									
Cancer Incidence	5.2E-8	5.2E-8	3.7E-8	N/A	3.6E-10	3.7E-10	3.6E-10	3.7E-10	N/A
NI Worker MEI									
Cancer Incidence	5.0E-11	5.0E-11	3.5E-11	N/A	3.5E-13	3.5E-13	3.5E-13	3.5E-13	N/A
Hazard Index	8.0E-10	8.0E-10	1.2E-8	N/A	5.6E-12	1.2E-10	5.6E-12	1.2E-10	N/A
Off-site Population									
Cancer Incidence	1.6E-7	1.6E-7	1.1E-7	N/A	1.1E-9	1.1E-9	1.1E-9	1.1E-9	N/A
Off-site MEI									
Cancer Incidence	8.1E-12	8.1E-12	5.7E-12	N/A	5.7E-14	5.7E-14	5.7E-14	5.7E-14	N/A
Hazard Index	1.3E-10	1.3E-10	1.9E-9	N/A	9.1E-13	1.9E-11	9.1E-13	1.9E-11	N/A
Involved Workers									
Cancer Incidence	3.0E-6	3.4E-6	5.2E-6	N/A	6.0E-7	5.2E-7	6.8E-7	5.2E-7	N/A
Exposure Index	3.0E-5	3.0E-5	3.0E-5	N/A	6.0E-6	3.0E-6	6.0E-6	N/A	N/A

[a] NI Worker Population dose is in person-rem
[b] NI Worker MEI dose is in rem
[c] Involved Worker Dose is in full time equivalent-rem

NI Worker = Noninvolved Worker
MEI = Maximally Exposed Individual
LCF = Latent Cancer Fatalities
N/A = Not Applicable

Table B-12
Human Health Impacts Associated with Treatment of RH-TRU Waste from Radionuclides and Chemicals in the Total Inventory

Receptor	Draft WM PEIS			SEIS-II					
	Decentralized (Draft WM PEIS Table D.3.4-27)	Regionalized 1 (Draft WM PEIS Table D.3.4-28)	Regionalized 2, 3, Centralized (Draft WM PEIS Table D.3.4-29)	Proposed Action	Action Alternative 1	Action Alternative 2	Action Alternative 3	No Action Alternative 1	No Action Alternative 2
Radionuclides									
NI Worker Population[a]									
Dose	4.5E-4	4.8E-4	3.6E+0	N/A	4.5E-4	3.6E+0	4.8E-4	3.6E+0	N/A
LCF	2.3E-7	2.4E-7	1.8E-3	N/A	2.3E-7	1.8E-3	2.4E-7	1.8E-3	N/A
NI Worker MEI[b]									
Dose	6.7E-7	7.0E-7	2.8E-3	N/A	6.7E-7	2.8E-3	7.0E-7	2.8E-3	N/A
LCF	3.4E-10	3.5E-10	1.4E-6	N/A	3.4E-10	1.4E-6	3.5E-10	1.4E-6	N/A
Off-site Population									
Dose	1.1E-2	1.1E-2	1.0E+2	N/A	1.1E-2	1.0E+2	1.1E-2	1.0E+2	N/A
LCF	5.3E-6	5.6E-6	5.2E-2	N/A	5.3E-6	5.2E-2	5.6E-6	5.2E-2	N/A
Off-site MEI									
Dose	1.8E-7	1.9E-7	2.8E-3	N/A	1.8E-7	2.8E-3	1.9E-7	2.8E-3	N/A
LCF	8.8E-11	9.3E-11	1.4E-6	N/A	8.8E-11	1.4E-6	9.3E-11	1.4E-6	N/A
Involved Workers[c]									
Dose	1.2E+1	1.3E+1	2.3E+2	N/A	3.5E+1	4.4E+2	3.8E+1	4.4E+2	N/A
LCF	4.9E-3	5.1E-3	9.3E-2	N/A	1.4E-2	1.8E-1	1.5E-2	1.8E-1	N/A
Chemicals									
NI Worker Population									
Cancer Incidence	5.2E-8	5.2E-8	3.7E-8	N/A	5.2E-8	3.7E-8	5.2E-8	3.7E-8	N/A
NI Worker MEI									
Cancer Incidence	5.0E-11	5.0E-11	3.5E-11	N/A	5.0E-11	3.5E-11	5.0E-11	3.5E-11	N/A
Hazard Index	8.0E-10	8.0E-10	1.2E-8	N/A	8.0E-10	1.2E-8	8.0E-10	1.2E-8	N/A
Off-site Population									
Cancer Incidence	1.6E-7	1.6E-7	1.1E-7	N/A	1.6E-7	1.1E-7	1.6E-7	1.1E-7	N/A
Off-site MEI									
Cancer Incidence	8.1E-12	8.1E-12	5.7E-12	N/A	8.1E-12	5.7E-12	8.1E-12	5.7E-12	N/A
Hazard Index	1.3E-10	1.3E-10	1.9E-9	N/A	1.3E-10	1.9E-9	1.3E-10	1.9E-9	N/A
Involved Workers									
Cancer Incidence	3.0E-6	3.4E-6	5.2E-6	N/A	8.7E-6	9.9E-6	9.9E-6	9.9E-6	N/A
Exposure Index	3.0E-5	3.0E-5	3.0E-5	N/A	8.7E-5	5.7E-5	8.7E-5	5.7E-5	N/A

[a] NI Worker Population dose is in person-rem
[b] NI Worker MEI dose is in rem
[c] Involved Worker Dose is in full time equivalent-rem

NI Worker = Noninvolved Worker
MEI = Maximally Exposed Individual
LCF = Latent Cancer Fatalities
N/A = Not Applicable

B.6 REFERENCES CITED IN APPENDIX B

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DOE (U.S. Department of Energy), 1995a, *Draft Waste Management Programmatic Environmental Impact Statement,* DOE/EIS-0200-D, August, Washington, D.C.

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APPENDIX C

APPENDIX C
AIR QUALITY

This appendix describes the methods used for analyzing potential impacts to air quality at the Waste Isolation Pilot Plant (WIPP) and the major treatment sites from routine emissions of nonradological air pollutants during normal operations of the facility. Pollutants addressed in this appendix include nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}), carbon monoxide (CO), lead (Pb) and volatile organic compounds (VOC) as ozone precursors. Lead and ozone would not be expected to be released in amounts of concern at WIPP. In formulating inputs for air quality modeling, a series of simplifying conservative assumptions have been used and are identified.

C.1 MODELS

The Industrial Source Complex (ISC3) computer code is used to estimate the annual air quality impacts. The ISC3 code consists of a short-term model (ISCST3) and a long-term model (ISCLT3). The long-term model was used to estimate annual air quality impacts. The short-term model was not used because the hourly meteorological data required by the model were not available at the time of the analysis. The model uses steady-state Gaussian plume algorithms to estimate pollutant concentrations from a wide variety of sources associated with industrial complexes (EPA 1995c). The model is appropriate for either flat or rolling terrain, modeling domains with a radius of 50 kilometers (31 miles) or less from the point of release, and either urban or rural environments. The ISC3 code is approved by the U.S. Environmental Protection Agency (EPA) for specific regulatory applications and is designed for use on personal computers. Input requirements for the ISC3 code include source configuration and pollutant emission parameters. The user may define point, line, area, or volume sources. The ISCLT3 code uses a joint frequency distribution of wind direction, wind speed, and atmospheric stability to compute pollutant transport and dispersion. Plume rise, stack tip downwash, and building wake can be computed, and plume depletion by deposition taken into account.

To calculate the short-term (24 hours or less) criteria pollutant impacts, the SCREEN3 model is used. SCREEN3 is a screening model used to estimate short-term air pollutant concentrations, including estimates of maximum ground-level concentrations from a single source (EPA 1995b). The model uses a steady-state Gaussian plume algorithm to calculate the concentration from a single point, area, or volume source of simple geometry. The model can be applied to both simple and complex terrain for modeling domains out to 100 kilometers (62 miles). Input requirements for SCREEN3 include source configuration information and pollutant emission parameters. Plume rise, building wake downwash, and plume impaction on complex terrain can be computed. While specific meteorological values of wind speed and stability can be entered to calculate pollutant transport and diffusion, the model can also calculate worst-case maximum concentrations, examining a range of stability classes and wind speeds to identify the most conservative meteorological conditions. Output of the SCREEN3 model is 1-hour maximum concentration at specified distances. Adjustment factors can be applied to estimate concentrations for averaging periods up to 24 hours. Averaging times and their corresponding adjustment or multiplying factors are shown in Table C-1 (EPA 1992). The SCREEN3 model is approved by EPA for specific screening procedures and is designed to run on personal computers.

Table C-1
Multiplying Factors to Estimate Maximum Concentration at Various Averaging Times for a Given 1-hour Maximum Concentration

Averaging Time	Multiplying Factor
3 hours	0.9
8 hours	0.7
24 hours	0.4

C.2 RECEPTORS

Maximum ground-level pollutant concentrations for regulation-specific time periods are reported at the maximally impacted receptor location. To determine maximum short-term impacts for exposure periods from 1 to 24 hours, pollutant concentrations for receptors along the "Off Limits Area" boundary are reported. Receptors along the "Off Limits Area" boundary are used because points along this boundary are the closest unrestricted access points to a member of the public. For long-term impacts, pollutant concentrations for receptors along the Land Withdrawal Boundary are reported. Points within the Land Withdrawal Boundary were not considered because of the limited time any member of the public would spend at an on-site location over the course of a year.

ISCLT3 model runs were done using a Cartesian grid of receptors spaced at 300-meter (984-foot) intervals along the Land Withdrawal Boundary. The model runs indicated that the maximum long-term concentrations would occur at a point approximately 3,000 meters (9,840 feet) north of the source. The maximum short-term concentrations for a ground level source would be at the closest point on the "Off Limits Area" boundary to the source, approximately 1,200 meters (3,940 feet) for the excavation exhaust stack.

C.3 SOURCE TERMS AND IMPACTS

The increase in airborne concentration of criteria pollutants is assumed to result from the routine operation of WIPP. Principal emission sources of particulates would be from fugitive salt dust, the excavation and disposal of salt, and fuel combustion from backup diesel-powered electrical generators and excavation and support equipment. Emissions of particulates are conservatively assumed to be emitted entirely as PM_{10}. Principal sources of NO_2, SO_2, and CO are from fuel combustion.

In all but one case, pollutants are assumed to be released from a point source. The exception to this is that wind erosion of the salt pile is assumed to come from an area source with a center located 360 meters (1,180 feet) north of the exhaust stack (see Figure 2-3). Plume rise is calculated for emissions from two back-up diesel generators and emissions out of the exhaust stack using stack parameters. Stack parameters for the generator (WEC 1993) and the exhaust shaft (DOE 1996) are given in Table C-2. Building wake downwash is not used in the model runs; however, there should be little difference between the concentration with and without building wake effects due to the large distances to receptors.

Table C-2
Stack Parameters for the Backup Generator and Exhaust Shaft

Parameter	Generator	Excavation Exhaust
Stack Height	4.57 meters	8.2 meters
Stack Diameter	0.305 meter	4.4 meters
Stack Temperature	619.3 Kelvin	288 Kelvin
Velocity of Gas	10.18 meters per second	4.66 meters per second

To calculate the annual and 24-hour impacts under the Proposed Action, the following operating schedule was used: (1) excavation operations performed in two 8-hour shifts per day, 5 days per week, 52 weeks per year; (2) contact-handled (CH) TRU waste disposal operations performed in two 8-hour shifts per day, 4 days per week, 52 weeks per year; (3) remote-handled (RH) TRU waste disposal operations performed in two 8-hour shifts per day, 4 days per week, 52 weeks per year; and (4) maintenance performed in one 8-hour shift per week, 52 weeks per year. This same schedule is assumed for Action Alternatives 1, 2, and 3. To calculate annual pollutant concentrations using the ISCLT2 model, a joint frequency distribution of wind speed, wind direction, and atmospheric stability data from Carlsbad, New Mexico, for the years 1990 through 1994 was used. A description of the meteorological data is found in Appendix F, Human Health.

No meteorological input is required for estimating the short-term averaged concentrations using the SCREEN3 model. SCREEN3 estimates the maximum concentration by examining a range of wind speed and stability classes to find the meteorological conditions.

C.3.1 Salt Dust Emissions

Salt dust emissions would result from wind erosion of the salt piles, emissions of salt through the ventilation system exhaust, and dust released from transferring the salt from the repository to the salt storage pile. Salt dust emissions were estimated using a ground-level release, a 1-meter-per-second wind, and an atmospheric stability class of F (stable).

Fugitive dust emissions from the salt pile have been conservatively estimated to be 6.44 kilograms per hectare (5.75 pounds per acre) per day of particulates (Tillman 1988b). The total area of the active salt pile for all alternatives except No Action Alternatives 1 and 2, because the salt piles would be disposed of during decommissioning, is assumed to be 12 hectares (30 acres) (DOE 1980). To estimate the annual emission, it is assumed that daily emission of fugitive dust is the same for each day of the year. The estimated daily emission rate is conservative because it does not take into account crusting, which would greatly reduce salt emission, and it assumes that the entire pile contains loose salt available for resuspension, when actually only a small portion of the pile would contain loose salt. The annual emission rate is also conservative. It is assumed that fugitive dust emissions occur each day when, in reality, fugitive dust emissions would only occur during high wind events.

The emission of particulates through the ventilation system is assumed to be 1.45 kilograms per hour (3.20 pounds per hour) (Tillman 1988a). Emission of salt through the ventilation system is assumed to be continuous during an entire 8-hour shift.

The dust released from transferring the salt from the repository to the storage pile is assumed to be 10 grams (0.36 ounces) per ton of salt moved to the pile (DOE 1980). On average, the amount of salt brought to the surface in all of the alternatives except No Action Alternatives 1 and 2 is assumed to be 5.4×10^5 kilograms (600 tons) per day and 1.4×10^8 kilograms (1.6×10^5 tons) per year (Ashford 1996).

Table C-3 summarizes the source term for PM_{10} emissions of salt dust for all alternatives except No Action Alternatives 1 and 2. Estimated impacts on air quality from salt dust emissions are shown in Table C-4.

Table C-3
Source Term for Calculating Salt Dust Emission Impacts for All Alternatives Except No Action Alternatives 1 and 2

Source	Averaging Time	Mass of Pollutant	Emission Rate
Wind Erosion	Annual	29,000 kilograms per year	7.5E-6 grams per square meter per second
	24 hour	78 kilograms per day	7.5E-6 grams per square meter per second
Emission From Ventilation	Annual	6,000 kilograms per year	0.19 grams per second
	24 hour	23 kilograms per day	0.27 grams per second
Emission during Transfer	Annual	1,600 kilograms per year	0.049 grams per second
	24 hour	6 kilograms per day	0.069 grams per second

Table C-4
Estimated Impacts on Air Quality from Salt Dust Emissions Under All Alternatives Except No Action Alternatives 1 and 2

Pollutant	Averaging Time	Maximum Concentration (micrograms per cubic meter)	Percent of Regulatory Limit	Regulatory Limit (micrograms per cubic meter)
PM_{10}	Annual	0.65	1.3	50[a]
	24 hour	78	52	150[a]

[a] Primary Federal Ambient Air Quality Standard (40 CFR Part 50)

C.3.2 Backup Generators

Four ambient air pollutants, NO_2, SO_2, CO, and PM_{10}, were assumed to be emitted by two 1,500-horsepower back-up diesel generators. A permit has been obtained by WIPP for the operation of these two back-up diesel generators (NMED 1993). Permit conditions have remained unchanged since 1993, with limits on the emissions of NO_2, SO_2, CO, and particulates. The generators are allowed to run, at most, 480 hours per year. Table C-5 summarizes the annual and hourly emission rate limits for the back-up diesel generators.

Table C-5
Maximum Annual and Hourly Emission Rates from Two Backup Generators

Pollutant	Averaging Time	Maximum Emission Rate
NO_2	Annual	10,000 kilograms per year
	Hourly	21 kilograms per hour
SO_2	Annual	730 kilograms per year
	Hourly	1.4 kilograms per hour
CO	Annual	2,220 kilograms per year
	Hourly	4.6 kilograms per hour
PM_{10}	Annual	730 kilograms per year
	Hourly	1.5 kilograms per hour

The source term for long-term impacts is assumed to be the maximum allowable annual emission rate of each pollutant as defined in the permit and the maximum allowable hourly emission rate as defined by the permit for short-term impacts. In addition, the backup generators were assumed to run for 6 hours per day for the short-term impacts. The maximum normal operating schedule is 6 hours per month, with 2 hours per month dedicated to ensure proper operation and the remaining 4 hours per month dedicated to periodic operational maintenance on the generators (WEC 1993).

Table C-6 summarizes the source terms for the emission of the four criteria pollutants for all alternatives except No Action Alternatives 1 and 2. The two no action alternatives are not included because they do not assume the use of the generators. Estimated potential air quality impacts are presented in Table C-7.

Table C-6
Source Term for Calculating Back-up Diesel Generator Emission Impacts

Pollutant	Averaging Time	Mass of Pollutant (kilograms) per Averaging Time	Emission Rate (grams per second)
NO_2	Annual	10,000	0.32
	24 hour	130	1.5
SO_2	Annual	730	0.023
	24 hour	8.4	0.098
	3 hour	1.4	0.39
CO	8 hour	27	0.95
	1 hour	4.6	1.3
PM_{10}	Annual	730	0.023
	24 hour	9.0	0.10

Table C-7
Criteria Pollutant Air Quality Impacts from the Emissions of Two Back-up Generators

Pollutant	Averaging Time	Maximum Concentration (micrograms per cubic meter)	Percent of Regulatory Limit	Regulatory Limit (micrograms per cubic meter)
NO_2	Annual	0.12	0.15	84[a]
	24 hour	54	32	168[a]
SO_2	Annual	0.0088	0.019	47[a]
	24 hour	3.6	0.015	234[a]
	3 hour	32	2.8	1,170[b]
CO	8 hour	63	0.69	8,700[a]
	1 hour	120	0.87	13,400[a]
PM_{10}	Annual	0.0088	0.018	50[c]
	24 hour	3.8	2.6	150[c]

[a] New Mexico Ambient Air Quality Standard (AQCR 201) corrected for altitude
[b] Secondary Federal Ambient Air Quality Standard (40 CFR Part 50) corrected for altitude
[c] Primary Federal Ambient Air Quality Standard (40 CFR Part 50)

C.3.3 Above Ground Diesel Equipment

In addition to the two back-up generators, the diesel equipment used on the surface during WIPP operations includes: one diesel dump truck used to haul the salt from the repository to the storage pile, a fire water pump, and an emergency hoist (Hollen 1996). All other equipment on the surface is electric.

To estimate the emissions from the diesel dump truck, emission rates for the criteria pollutants for heavy-duty construction equipment found in EPA's *Supplement A to Compilation of Air Pollution Emission Factors, Volume 2: Mobile Sources* (EPA 1991, Table 2-7.1) were used. These emission rates are summarized in Table C-8. Pollutant emissions are estimated using the emission rate for diesel industrial engines found in EPA's *Compilation of Air Pollution Emission Factors, Volume 1: Stationary Point and Area Sources, 5th Edition* (EPA 1995a, Table 3.3-2) for the fire water pump and emergency hoist. These emission rates are summarized in Table C-9.

Truck operation is assumed to be 40 percent of an 8-hour shift, to account for start up and shutdown of the excavation operation during a shift, operator break and lunch periods, and the time when salt is being loaded in the truck. For the other diesel equipment used during routine operations, it is assumed that the fire water pump (188 horsepower) is in operation for 30 minutes per week and the emergency hoist (115 horsepower) is in operation for 30 minutes per month (Hollen 1996).

Table C-10 summarizes the source term for emissions of the above-ground diesel equipment for all alternatives except No Action Alternatives 1 and 2, which do not assume operation of any of the above-ground diesel equipment. The potential air quality impacts are shown in Table C-11.

Table C-8
Estimated Emission Rates for Diesel Dump Truck

Pollutant	Estimated Emission Rate (grams per hour of operation)
NO_2	1,900
SO_2	210
CO	820
PM_{10}	120

Table C-9
Estimated Emission Rates for Industrial Diesel Engines

Pollutant	Estimated Emission Rate (pounds per horsepower-hour)
NO_2	0.031
SO_2	0.00205
CO	0.00668
PM_{10}	0.00220

Table C-10
Source Term for Calculating Impacts from Surface Diesel Equipment

Pollutant	Averaging Time	Mass of Pollutant (kilograms) per Averaging Time	Emission Rate (grams per second)
NO_2	Annual	3,200	0.10
	24 hour	14	0.16
SO_2	Annual	350	0.011
	24 hour	1.5	0.017
	3 hour	0.76	0.070
CO	8 hour	3.1	0.11
	1 hour	1.3	0.35
PM_{10}	Annual	200	0.0063
	24 hour	0.89	0.010

Table C-11
Criteria Pollutant Air Quality Impacts from Surface Diesel Equipment Emissions

Pollutant	Averaging Time	Maximum Concentration (micrograms per cubic meter)	Regulatory Limit (micrograms per cubic meter)	Percent of Regulatory Limit
NO_2	Annual	0.050	84[a]	0.060
	24 hour	33	168[a]	20
SO_2	Annual	0.0054	47[a]	0.012
	24 hour	3.4	234[a]	0.015
	3 hour	32	1,170[b]	2.7
CO	8 hour	38	8,900[a]	0.43
	1 hour	180	13,400[a]	1.3
PM_{10}	Annual	0.0031	50[c]	0.0062
	24 hour	2.1	150[c]	1.4

[a] New Mexico Ambient Air Quality Standard (AQCR 201) corrected for altitude
[b] Secondary Federal Ambient Air Quality Standard (40 CFR Part 50) corrected for altitude
[c] Primary Federal Ambient Air Quality Standard (40 CFR Part 50)

C.3.4 Underground Diesel Equipment

A variety of diesel equipment is used in underground excavation, disposal, and maintenance operations, although only a few pieces of equipment are in operation at any one time (WEC 1995). To estimate the impacts from underground equipment, the pollutant emissions are estimated using the emission rates for diesel industrial engines found in EPA's *Compilation of Air Pollution Emission Factors, Volume 1: Stationary Point and Area Sources, 5th Edition* (EPA 1995a, Table 3.3-2). These emission rates are summarized in Table C-9 above.

The pollution emission for the underground diesel equipment depends upon the usage, the rated power available, and the load factor (the power actually used divided by the power available for each engine). Underground diesel equipment usage is assumed to be 40 percent of an 8-hour shift, to account for start up and shutdown of the excavation operation during a shift, operator break and lunch periods, and the time in which the equipment is not in use. To estimate the power available, a typical number and type of equipment are assumed for the excavation operation, CH-TRU waste handling, RH-TRU waste handling, and maintenance. Table C-12 shows the estimated equipment used in normal excavation, disposal, and maintenance operations (Roland 1996) along with the total available power for equipment used during a particular operation (WEC 1995). With the exception of impacts of less than three hours, a load factor of 40 percent is assumed because the equipment will normally not be running at full power. For impacts of less than three hours, the equipment is assumed to be running at full power and a load factor of 100 percent is used.

Table C-13 summarizes the source term for pollutant emissions from underground equipment. The potential air quality impacts resulting from underground equipment use are shown in Table C-14. The short-term impacts are highly conservative because they assume that the emissions are directly from the stack and do not enter into the repository where they would be diluted.

Table C-12
Diesel Equipment and Total Available Power for Underground Operations

Operation	Equipment Used	Total Available Power (horsepower)
Excavation	4 Trucks, 2 Load Haul Dumps	709
CH-TRU Waste Disposal	2 CH-TRU Waste Transports and 1 6-ton Forklift	298
RH-TRU Waste Disposal	1 40-ton Forklift and 1 20-ton Forklift	416
Maintenance	Scissor Lift, Arc Welder, 2 Tractors, Lube Truck	255

Table C-13
Source Term for Calculating Impacts from Underground Diesel Equipment Emissions

Pollutant	Averaging Time	Mass of Pollutant (kilograms) per Averaging Time	Emission Rate (grams per second)
NO_2	Annual	12,000	0.39
	24 hour	51	0.59
SO_2	Annual	810	0.026
	24 hour	3.4	0.039
	3 hour	0.53	0.15
CO	8 hour	5.5	0.19
	1 hour	4.3	1.2
PM_{10}	Annual	870	0.0275
	24 hour	3.6	0.042

Table C-14
Criteria Pollutant Air Quality Impacts from Underground Diesel Equipment Emissions

Pollutant	Averaging Time	Maximum Concentration (micrograms per cubic meter)	Regulatory Limit (micrograms per cubic meter)	Percent of Regulatory Limit
NO_2	Annual	0.11	84[a]	0.13
	24 hour	23	168[a]	14
SO_2	Annual	0.0073	47[a]	0.015
	24 hour	1.5	234[a]	0.63
	3 hour	13	1,170[b]	1.1
CO	8 hour	13	8,900[a]	0.14
	1 hour	110	13,400[a]	0.85
PM_{10}	Annual	0.0078	50[c]	0.016
	24 hour	1.6	150[c]	1.1

[a] New Mexico Ambient Air Quality Standard (AQCR 201) corrected for altitude
[b] Secondary Federal Ambient Air Quality Standard (40 CFR Part 50) corrected for altitude
[c] Primary Federal Ambient Air Quality Standard (40 CFR Part 50)

C.3.5 Decommissioning of WIPP

The plans for decommissioning WIPP are described in Section 3.1.3.5. The potential air quality impacts would mainly come from construction of the berm and permanent markers, dismantling the above-ground structures (approximately 8 hectares [20 acres] of buildings outside the surface marker area), and reclamation of the salt stored on the surface. The impacts would be from fugitive dust due to construction operations and emissions from heavy-duty construction equipment.

Impacts from the dismantling of the above-ground building and construction of the berm and permanent markers would be similar to the impacts described in the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS), which describes the construction impacts for building the WIPP site. The same type of construction equipment would be used. Although the area of the berm varies between the Proposed Action and each of the action alternatives, the yearly usage of equipment and the number of acres of land disturbed by construction in a year is assumed to be similar. No Action Alternatives 1 and 2 would not require the building of the berm or setting up the permanent markers and would have smaller air quality impacts than those for the other alternatives.

Air quality impacts would also be due to reclaiming the stored salt on the surface. Stored salt could be used to close the shafts of the repository or act as a base for the berm. Emissions of criteria pollutants and the resulting air quality impacts from the shaft closure operations would be similar to those described in the FEIS. These include emissions from a mined-salt drier, loading the salt into a crusher, transporting the salt into the repository, and salt emitted out of the ventilation system. Impacts for using the reclaimed salt as the base to the berm would be similar to those for using the reclaimed salt to close the shafts since drying, crushing, and transport of the salt would be required for both. As the existing salt pile is smaller than the 12-hectare (30-acre) storage pile assumed under the Proposed Action and the action alternatives, emission and impacts from reclaiming the salt pile in No Action Alternatives 1 and 2 would be less than for the other alternatives.

C.3.6 Volatile Organic Compounds

VOC emissions were estimated using drum headspace volatile emission data (detailed in Appendix F). Emission rates for all of the individual VOCs listed were summed, and the one panel-equivalent of CH-TRU waste and RH-TRU waste (about 85,000 drum-equivalents for all alternatives) was assumed to be continuously releasing volatiles. The estimated total VOC emissions in the New Mexico Prevention of Significant Deterioration (PSD) regulations (Air Quality Control Regulation [AQCR]) was 540 kilograms (1,200 pounds) per year. VOCs were based on this PSD regulation because they are ozone precursors. These emissions did not vary greatly among the Proposed Action, Action Alternative 1, and Action Alternative 3. No VOCs would be present in the thermally treated waste under Action Alternative 2 and No Action Alternative 1.

C.3.7 Criteria Air Pollutants at Generator-Storage and Treatment Sites

DOE evaluated air quality impacts at each proposed waste management site based on estimated increases in emissions of the six criteria air pollutants. Pollutant emission estimates were made for the construction and operation and maintenance activities of the waste management facilities.

In those areas where air pollution standards are not met (nonattainment areas), activities that introduce new sources of emissions are regulated under the General Conformity Rule. In areas where air pollution standards are met (attainment areas), regulations for the PSD of ambient air quality apply. In both cases, a permit is required for sources which will result in emissions equal to or greater than the limits set by pertinent regulations.

Criteria air pollutants can be emitted from construction equipment and from vehicles used to drive to the construction site; both are considered to be mobile sources. Criteria air pollutants are also emitted during operation and maintenance of waste management facilities (stationary sources) and by vehicles that are driven to the facility or used to transport waste (mobile sources). DOE evaluated air quality impacts for these pollutants at each site by comparing the estimated increases in tons per year to the allowable emission limits under either the General Conformity Rules in nonattainment areas or the PSD regulations in attainment areas.

Table C-15 at the end of this appendix shows the percent of standard/guidelines for emissions of criteria air pollutants during operation and maintenance at nine of the ten major generator-storage sites. Data are taken from the *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS) (DOE 1995). Data for the Mound Plant were not included in the Draft WM PEIS.

Table C-16 at the end of this appendix shows the percent of the General Conformity Rule for emissions of criteria air pollutants during construction at four of the ten major generator-storage sites, where data are available. Data are taken from the Draft WM PEIS (DOE 1995).

C.4 REFERENCES CITED IN APPENDIX C

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WEC (Westinghouse Electric Corporation), 1995, "Waste Isolation Pilot Plant Mine Ventilation Plan," Carlsbad, New Mexico.

Table C-15
Percent of Standard/Guidelines for Criteria Air Pollutants During Operations and Maintenance

Pollutant	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Argonne National Laboratory-East									
CO	0	0	0	0	0	0	0	0	0
NO_2	9	9	8	8	8	5	8	8	5
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	0	0	0	0	0	0	0
SO_2	0	0	0	0	0	0	0	0	0
VOC	5	5	5	5	5	5	5	5	3
Hanford Site									
CO	0	0	0	0	0	0	0	0	0
NO_2	2	2	2	2	1	2	2	2	1
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	1	1	2	2	1	1	2	2	0
SO_2	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0
Idaho National Engineering Laboratory									
CO	0	0	0	1	0	0	0	1	0
NO_2	1	1	2	4	0	2	2	4	1
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	1	1	10	17	0	1	10	17	0
SO_2	0	0	4	8	0	0	4	8	0
VOC	0	0	0	0	0	0	0	0	0
Lawrence Livermore National Laboratory									
CO	8	8	9	9	9	6	9	9	3
NO_2	2	2	2	2	2	1	2	2	1
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	0	0	0	0	0	0	0
SO_2	0	0	0	0	0	0	0	0	0
VOC	2	2	2	2	2	1	2	2	1
Los Alamos National Laboratory									
CO	0	0	0	0	0	0	0	0	0
NO_2	1	1	2	0	0	1	2	0	0
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	5	0	0	0	5	0	0
SO_2	0	0	2	0	0	0	2	0	0
VOC	0	0	0	0	0	0	0	0	0
Nevada Test Site									
CO	3	3	0	0	0	0	0	0	2
NO_2	0	0	0	0	0	0	0	0	0
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	0	0	0	0	0	0	0
SO_2	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0
Oak Ridge National Laboratory									
CO	0	0	0	0	0	0	0	0	0
NO_2	1	1	1	1	1	0	1	1	0
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	2	2	2	0	2	2	0
SO_2	0	0	1	1	1	0	1	1	0
VOC	0	0	0	0	0	0	0	0	0
Rocky Flats Environmental Technology Site									
CO	17	17	24	5	5	20	24	5	8
NO_2	4	4	5	1	1	4	5	1	2
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	0	0	0	0	0	0	0
SO_2	0	0	1	0	0	0	1	0	0
VOC	4	4	6	1	1	5	6	1	2
Savannah River Site									
CO	0	0	0	0	0	0	0	0	0
NO_2	1	1	2	2	0	1	2	2	0
Pb	0	0	0	0	0	0	0	0	0
PM_{10}	0	0	9	9	0	1	9	9	0
SO_2	0	0	4	4	0	0	4	4	0
VOC	0	0	0	0	0	0	0	0	0

Source: Draft WM PEIS (DOE 1995)

Table C-16
Percent of General Conformity Rule for Criteria Air Pollutants During Construction

Pollutant	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Argonne National Laboratory-East									
CO	-	-	-	-	-	-	-	-	-
NO_2	49	49	34	34	34	40	34	34	-
Pb	-	-	-	-	-	-	-	-	-
PM_{10}	1	1	1	1	1	0	1	1	-
SO_2	-	-	-	-	-	-	-	-	-
VOC	17	17	8	8	8	16	8	8	-
Los Alamos National Laboratory									
CO	13	13	20	20	20	9	20	20	-
NO_2	7	7	10	10	10	3	10	10	-
Pb	0	0	0	0	0	0	0	0	-
PM_{10}	0	0	0	0	0	0	0	0	-
SO_2	0	0	0	0	0	0	0	0	-
VOC	4	4	5	5	5	2	5	5	-
Nevada Test Site									
CO	5	5	0	0	0	0	0	0	-
NO_2	-	-	-	-	-	-	-	-	-
Pb	-	-	-	-	-	-	-	-	-
PM_{10}	0	0	0	0	0	0	0	0	-
SO_2	-	-	-	-	-	-	-	-	-
VOC	-	-	-	-	-	-	-	-	-
Rocky Flats Environmental Technology Site									
CO	19	19	29	7	7	20	29	7	-
NO_2	11	11	15	4	4	11	15	4	-
Pb	-	-	-	-	-	-	-	-	-
PM_{10}	1	1	1	0	0	1	1	0	-
SO_2	-	-	-	-	-	-	-	-	-
VOC	6	6	8	2	2	6	8	2	-

Source: Draft WM PEIS (DOE 1995)

APPENDIX D

APPENDIX D
LIFE-CYCLE COSTS AND ECONOMIC IMPACTS

This appendix discusses the technical approach and sources of information used in the estimation of life-cycle costs and economic impacts of *Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II) alternatives.

D.1 LIFE-CYCLE COSTS

Life-cycle costs were determined in three areas: waste management facility costs at the large waste consolidation sites, waste transportation costs to the Waste Isolation Pilot Plant (WIPP) site, and WIPP operations costs.

D.1.1 Waste Treatment Facility Costs

The *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS) cost estimates for waste management facilities include the following major cost elements (DOE 1995a):

- Preoperations costs - These include the costs of technology site adaptation, including bench tests and demonstrations; statutory and regulatory permitting; plant setup costs; and related generic design, project management, and contingencies.

- Facility construction costs - These include the costs of buildings, equipment, and related design; construction and project management; and contingencies.

- Operations and maintenance costs - These include the costs of annual operations, maintenance, utilities, contractor supervision and overhead, and related project management and contingencies.

- Decontamination and decommissioning costs - These include the costs of demolition of facilities, environmental closure, post closure and monitoring activities.

The Draft WM PEIS also provided an equivalent accounting or breakdown of waste management facility costs on the basis of waste management functions performed at sites, including:

- Waste retrieval and characterization - These include the costs to retrieve and characterize the constituents prior to and following treatment.

- Waste treatment costs - These include the costs to build, operate and maintain waste treatment facilities.

- Waste storage costs - These include the costs to build, operate, and maintain storage capacity at the large waste consolidation sites.

The cost information provided in data tables in the Draft WM PEIS provided a benchmark for estimating waste management facility costs for the SEIS-II alternatives. Tables D-1 through D-8 present these estimates. Costs were calculated by adjusting the site costs provided in the Draft

Table D-1
Waste Treatment Facility Costs for the Proposed Action in Millions of 1994 Dollars[a]

Cost Components	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	Costs[b]
Draft WM PEIS Decentralized Alternative Site Costs								
INEL/ANL-W	$83	$419	$725	$461	$930	$705	$54	$1,688
Hanford	$110	$403	$960	$338	$584	$1,188	$39	$1,810
SRS	$30	$134	$251	$90	$15	$457	$33	$505
LANL	$50	$237	$397	$234	$454	$438	$27	$919
RFETS	$21	$95	$227	$34	$46	$311	$20	$377
ORNL	$33	$151	$286	$81	$109	$415	$28	$551
Mound	$12	$37	$62	$12	$12	$99	$12	$124
LLNL	$17	$63	$132	$21	$0	$221	$14	$233
NTS	$6	$27	$46	$17	$0	$84	$12	$96
ANL-E	$25	$89	$183	$33	$0	$308	$22	$330
Total	---	---	---	---	---	---	---	$6,633
SEIS-II Proposed Action Alternative Site Costs								
INEL/ANL-W	$67	$339	$587	$373	$753	$571	$44	$1,367
Hanford	$377	$1,382	$3298	$1,159	$2,003	$4,075	$134	$6,212
SRS	$21	$95	$178	$64	$11	$324	$23	$359
LANL	$96	$455	$762	$449	$872	$841	$52	$1,763
RFETS	$37	$166	$397	$60	$81	$544	$35	$660
ORNL	$67	$308	$584	$165	$222	$847	$57	$1,124
Mound	$2	$7	$13	$2	$2	$20	$2	$25
LLNL	$12	$44	$93	$15	$0	$155	$10	$163
NTS	$6	$28	$48	$18	$0	$87	$12	$100
ANL-E	$4	$13	$28	$5	$0	$46	$3	$50
Total	$690	$2,839	$5,986	$2,310	$3,944	$7,510	$373	$11,821
Total Discounted at 4.1 Percent	$383	$1,574	$3,317	$1,281	$2,187	$4,165	$207	$6,555

Consolidated Site Volumes	WM PEIS CH-TRU Waste	WM PEIS RH-TRU Waste	WM PEIS Total	SEIS-II CH-TRU Waste	SEIS-II RH-TRU Waste	SEIS-II Total	Volume Adjustment Factor
INEL/ANL-W	38,000	610	38,610	29,157	1,956	31,114	0.81
Hanford	19,000	6,300	25,300	57,491	29,425	86,916	3.43
SRS	17,000	0	17,000	12,065	0	12,065	0.71
LANL	11,000	89	11,089	21,048	228	21,276	1.92
RFETS	6,200	0	6,200	10,862	0	10,862	1.75
ORNL	1,000	1,700	2,700	1,849	3,666	5,515	2.04
Mound	1,500	0	1,500	301	0	301	0.20
LLNL	1,700	0	1,700	1,195	0	1,195	0.70
NTS	610	0	610	633	0	633	1.04
ANL-E	960	340	1,300	201	0	201	0.15
Total	96,970	9,039	106,009	134,802	35,276	170,078	---

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and is also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

WM PEIS (Tables II-2.3-12 through II-16.3-12) by the ratio of SEIS-II waste volumes relative to Draft WM PEIS waste volumes. As an example, consider the case of the Proposed Action reported in Table D-1.

In the Draft WM PEIS, the Hanford Site (Hanford) would process a total of 25,300 cubic meters (895,000 cubic feet) of waste, whereas in SEIS-II, it would process a total of 86,900 cubic meters (3,070,000 cubic feet), or 3.43 times the reported Draft WM PEIS volume. Accordingly, the adjusted waste management facility costs at Hanford under the Proposed Action are approximately $6.2 billion -- the product of the original Draft WM PEIS cost estimate of $1.81 billion and the volume adjustment factor -- that is, $1.81 x 3.43 = $6.2 billion (in 1994 dollars).

Table D-2
Waste Treatment Facility Costs for Action Alternative 1
in Millions of 1994 Dollars[a,b]

Cost Components	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	Costs[c]
Draft WM PEIS Decentralized Alternative Site Costs								
INEL/ANL-W	$83	$419	$725	$461	$930	$705	$54	$1,688
Hanford	$110	$403	$960	$338	$584	$1,188	$39	$1,811
SRS	$30	$134	$251	$90	$15	$457	$33	$505
LANL	$50	$237	$397	$234	$454	$438	$27	$918
RFETS	$21	$95	$227	$34	$46	$311	$20	$377
ORNL	$33	$151	$286	$81	$109	$415	$28	$551
Mound	$12	$37	$62	$12	$12	$99	$12	$124
LLNL	$17	$63	$132	$21	$0	$221	$14	$234
NTS	$6	$27	$46	$17	$0	$84	$12	$96
ANL-E	$25	$89	$183	$33	$0	$308	$22	$330
Total	---	---	---	---	---	---	---	$6,634
SEIS-II Action Alternative 1 Site Costs								
INEL/ANL-W	$189	$955	$1,876	$1,051	$2,120	$1,607	$346	$4,074
Hanford	$655	$2,398	$6,132	$2,011	$3,475	$7,069	$652	$11,195
SRS	$30	$134	$251	$90	$15	$457	$33	$505
LANL	$159	$754	$1,262	$744	$1,444	$1,393	$86	$2,922
RFETS	$37	$166	$397	$60	$81	$544	$35	$660
ORNL	$94	$430	$867	$231	$311	$1,183	$132	$1,625
Mound	$2	$7	$12	$2	$2	$20	$2	$25
LLNL	$2	$8	$16	$3	$0	$27	$2	$28
NTS	$12	$53	$90	$33	$0	$165	$24	$188
ANL-E	$12	$44	$90	$16	$0	$151	$11	$162
Total	$1,192	$4,949	$10,994	$4,241	$7,448	$12,615	$1,322	$21,385
Total Discounted at 4.1 Percent	$661	$2,744	$6,097	$2,352	$4,130	$6,996	$733	$11,859

Consolidated Site Volumes	WM PEIS CH-TRU Waste	WM PEIS RH-TRU Waste	WM PEIS Total	SEIS-II CH-TRU Waste	SEIS-II RH-TRU Waste	SEIS-II Total	Volume Adjustment Factor
INEL/ANL-W	38,000	610	38,610	85,714	2,400	88,114	2.28
Hanford	19,000	6,300	25,300	120,092	30,455	150,547	5.95
SRS	17,000	0	17,000	16,939	0	16,939	1.00
LANL	11,000	89	11,089	34,931	347	35,278	3.18
RFETS	6,200	0	6,200	10,862	0	10,862	1.75
ORNL	1,000	1,700	2,700	2,110	5,585	7,695	2.85
Mound	1,500	0	1,500	301	0	301	0.20
LLNL	1,700	0	1,700	201	0	201	0.12
NTS	610	0	610	1,195	0	1,195	1.96
ANL-E	960	340	1,300	633	0	633	0.49
Total	96,970	9,039	106,009	272,977	38,787	311,764	---

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($420 million), INEL ($223 million), and ORNL ($52 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and is also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

This adjustment process was applied to each site for the various SEIS-II alternatives. Due to the absence of Draft WM PEIS cost information for the Mound Plant (Mound), its benchmark cost estimate reflects the average costs of other sites having relatively small waste volumes.

The adjustment process described above is appropriate provided that linear relationships exist between costs and waste volumes and treatment rates considered for the SEIS-II alternatives fall within the range of operations considered in the Draft WM PEIS. To verify that these cost conditions are satisfied, guidance provided in Feizollahi and Shropshire (1994, Table 1-1) was considered. Specifically, cost relationships involving treatment processing rates (in kilograms per

Table D-3
Waste Treatment Facility Costs for Action Alternative 2A in Millions of 1994 Dollars[a,b]

Cost Components	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	Costs[c]
Draft WM PEIS Regionalized 2 Alternative Site Costs								
INEL/ANL-W	$125	$549	$875	$493	$930	$1,023	$90	$2,042
Hanford	$187	$679	$1,241	$384	$584	$1,813	$95	$2,491
SRS	$87	$327	$509	$100	$15	$982	$28	$1,024
LANL	$56	$250	$480	$245	$454	$539	$37	$1,031
RFETS	$34	$145	$303	$49	$46	$457	$29	$531
ORNL	$64	$207	$335	$72	$109	$554	$14	$678
Total	---	---	---	---	---	---	---	$7,797
SEIS-II Action Alternative 2 A Site Costs								
INEL/ANL-W	$281	$1,235	$1,969	$1,109	$2,093	$2,302	$203	$4,597
Hanford	$1,144	$4,155	$7,983	$2,350	$3,574	$11,096	$969	$15,639
SRS	$100	$376	$585	$115	$17	$1,129	$32	$1,179
LANL	$176	$788	$1,512	$772	$1,430	$1,698	$117	$3,245
RFETS	$60	$254	$530	$86	$81	$800	$51	$931
ORNL	$132	$428	$693	$149	$226	$1,147	$29	$1,401
Preliminary Treatment	$42	$183	$359	$120	$134	$527	$42	$703
Total	$1,936	$7,419	$13,631	$4,700	$7,554	$18,698	$1,443	$27,695
Total Discounted at 4.1 Percent	$1,074	$4,114	$7,559	$2,607	$4,189	$10,369	$800	$15,358

Consolidated Site Volumes	WM PEIS CH-TRU Waste	WM PEIS RH-TRU Waste	WM PEIS Total	SEIS-II CH-TRU Waste	SEIS-II RH-TRU Waste	SEIS-II Total	Volume Adjustment Factor
INEL/ANL-W	38,000	610	38,610	86,811	0	86,811	2.25
Hanford	19,000	6,300	25,300	121,529	33,202	154,731	6.12
SRS	17,000	0	17,000	19,567	0	19,567	1.15
LANL	11,000	89	11,089	34,931	0	34,931	3.15
RFETS	6,200	0	6,200	10,862	0	10,862	1.75
ORNL	1,000	1,700	2,700	0	5,585	5,585	2.07
Total	96,970	9,039	106,009	273,700	38,787	312,486	---

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($388 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and is also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

hour), storage input/throughput rates (in cubic meters per hour), and storage total volumetric requirements (in cubic meters) were considered.

The operation rates implied by a 35-year period do not exceed the maximum rate (or scale) of operations referenced in Feizollahi and Shropshire (1994) at any of the sites for any of the SEIS-II alternatives. However, the operations rates implied by a 35-year period did fall below the minimum boundary identified in Feizollahi and Shropshire (1994) at several sites having relatively small consolidated waste volumes. Consequently, the rate of operations at these sites were increased by reducing the period of operations to less than 35 years. As a result, operation rates at Mound, Lawrence Livermore National Laboratory (LLNL), Argonne National Laboratory - East (ANL-E) and the Nevada Test Site (NTS) were increased by shortening the period of operations to less than 35 years.

In the cases of Action Alternatives 1, 2, and 3, the site storage costs at Hanford, Idaho National Engineering Laboratory (INEL), and Oak Ridge National Laboratory (ORNL) extend beyond the 35-year waste processing period. These storage-cost adjustments are made to account for extended

Table D-4
Waste Treatment Facility Costs for Action Alternative 2B in Millions of 1994 Dollars[a,b]

Cost Components	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	Costs[c]
Draft WM PEIS Regionalized 3 Alternative Site Costs								
INEL/ANL-W	$157	$680	$1,140	$508	$930	$1,456	$100	$2,485
Hanford	$187	$679	$1,241	$384	$584	$1,813	$95	$2,491
SRS	$87	$327	$509	$100	$15	$982	$28	$1,023
ORNL	$64	$207	$335	$72	$109	$554	$14	$678
Total	---	---	---	---	---	---	---	$6,677
SEIS-II Action Alternative 2B Site Costs								
INEL/ANL-W	$539	$2,332	$3,910	$1,742	$3,190	$4,994	$343	$8,527
Hanford	$1,144	$4,155	$7,595	$2,350	$3,574	$11,096	$581	$15,251
SRS	$100	$376	$585	$115	$17	$1,129	$32	$1,179
ORNL	$132	$428	$693	$149	$226	$1,147	$29	$1,401
Preliminary Treatment	$228	$989	$1,941	$647	$723	$2,854	$228	$3,805
Total	$2,144	$8,282	$14,725	$5,003	$7,730	$21,220	$1,214	$30,164
Total Discounted at 4.1 Percent	$1,189	$4,593	$8,166	$2,775	$4,287	$11,767	$673	$16,727

Consolidated Site Volumes	WM PEIS CH-TRU Waste	WM PEIS RH-TRU Waste	WM PEIS Total	SEIS-II CH-TRU Waste	SEIS-II RH-TRU Waste	SEIS-II Total	Volume Adjustment Factor
INEL/ANL-W	38,000	610	38,610	132,604	0	132,604	3.43
Hanford	19,000	6,300	25,300	121,529	33,202	154,731	6.12
SRS	17,000	0	17,000	19,567	0	19,567	1.15
ORNL	1,000	1,700	2,700	0	5,585	5,585	2.07
Total	96,970	9,039	106,009	273,700	38,787	312,486	---

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($388 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and is also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

Table D-5
Waste Treatment Facility Costs for Action Alternative 2C in Millions of 1994 Dollars[a,b]

Cost Components	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	Costs[c]
Draft WM PEIS Centralized Alternative Site Costs								
Hanford	$128	$445	$917	$323	$584	$1,180	$49	$1,813
ORNL	$64	$207	$335	$72	$109	$554	$14	$678
WIPP	$185	$832	$1,243	$86	$0	$2,346	$0	$2,346
Total								$4,837
SEIS-II Action Alternative 2C Site Costs								
Hanford	$166	$579	$1,580	$420	$759	$1,534	$453	$2,745
ORNL	$132	$428	$693	$149	$226	$1,147	$29	$1,401
WIPP	$478	$2,148	$3,207	$222	0	$6,057	0	$6,057
Preliminary Treatment	$1,109	$4,807	$9,430	$3,143	$3,513	$13,867	$1,109	$18,490
Totals	$1,886	$7,961	$14,910	$3,934	$4,498	$22,601	$1,590	$28,689
Total Discounted at 4.1 percent	$1,046	$4,415	$8,268	$2,182	$2,494	$12,533	$882	$15,909

Treatment Site Volumes	WM PEIS CH-TRU Waste	WM PEIS RH-TRU Waste	WM PEIS Total	SEIS-II CH-TRU Waste	SEIS-II RH-TRU Waste	SEIS-II Total	Volume Adjustment Factor
Hanford	19,000	6,300	25,300	0	33,000	33,000	1.30
ORNL	1,000	1,700	2,700	0	5,600	5,600	2.07
WIPP	96,970	9,039	106,009	273,700	0	273,700	2.58

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($388 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and is also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

Table D-6
Waste Treatment Facility Costs for Action Alternative 3
in Millions of 1994 Dollars[a,b]

Cost Components	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval	Treatment	Storage	Costs[c]
Draft WM PEIS Regionalized 1 Alternative Site Costs								
INEL/ANL-W	$105	$450	$777	$489	$930	$801	$91	$1,821
Hanford	$156	$480	$1,116	$371	$584	$1,446	$93	$2,123
SRS	$68	$246	$421	$120	$15	$780	$61	$855
LANL	$56	$260	$405	$240	$454	$468	$39	$961
RFETS	$22	$98	$257	$45	$46	$346	$30	$422
ORNL	$45	$120	$247	$68	$109	$353	$19	$480
Total								$6,662
SEIS-II Action Alternative 3 Site Costs								
INEL/ANL-W	$235	$1,008	$2,006	$1,095	$2,083	$1,794	$470	$4,347
Hanford	$953	$2,933	$7,319	$2,267	$3,568	$8,835	$1,068	$13,472
SRS	$78	$283	$484	$138	$17	$897	$70	$984
LANL	$176	$819	$1,276	$756	$1,430	$1,474	$123	$3,027
RFETS	$39	$172	$450	$79	$81	$606	$53	$739
ORNL	$93	$248	$663	$141	$226	$731	$191	$1,148
Preliminary Treatment	$38	$167	$327	$109	$122	$481	$38	$641
Total	$1,613	$5,629	$12,525	$4,585	$7,527	$14,818	$2,013	$24,358
Total Discounted at 4.1 Percent	$914	$3,188	$7,094	$2,597	$4,263	$8,392	$1,140	$13,795

Consolidated Site Volumes	WM PEIS CH-TRU Waste	WM PEIS RH-TRU Waste	WM PEIS Total	SEIS-II CH-TRU Waste	SEIS-II RH-TRU Waste	SEIS-II Total	Volume Adjustment Factor
INEL/ANL-W	38,000	610	38,610	86,350	0	86,350	2.24
Hanford	19,000	6,300	25,300	121,287	33,202	154,489	6.11
SRS	17,000	0	17,000	19,548	0	19,548	1.15
LANL	11,000	89	11,089	34,931	0	34,931	3.15
RFETS	6,200	0	6,200	10,862	0	10,862	1.75
ORNL	1,000	1,700	2,700	0	5,585	5,585	2.07
Total	96,970	9,039	106,009	272,977	38,787	311,764	---

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] Lag storage costs are included for Hanford ($500 million), INEL ($266 million), and ORNL ($152 million).
[c] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and is also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

storage periods ranging from 100 to 155 years due to WIPP emplacement limitations for remote-handled (RH) transuranic (TRU) waste. Thus, the storage costs at these sites reflect periodic expenditures made every 35 years over the waste work-off period and are calculated on the basis of the remaining site inventories at the end of each period. In this way, storage costs decrease on a periodic basis over the life of the alternative as waste inventories are shipped to WIPP for disposal. Care was taken to reduce the number of sites requiring extended storage by adjusting treatment-shipment rates among the various sites, provided it did not interfere with waste handling limitations or compromise WIPP emplacement capacity. This resulted in fewer lagged storage sites than the number considered in Appendix F.

D.1.2 Waste Transport Costs

The waste transport costs for contact-handled (CH) TRU and RH-TRU waste vary by alternative, depending on the mode of transportation and the total mileage and number of shipments required for disposal of the waste volumes. Two sources of information for the estimation of waste transportation costs were used: (1) the *Engineered Alternatives Cost/Benefit Study Final Report*

Table D-7
Waste Treatment Facility Costs for No Action Alternative 1A in Millions of 1994 Dollars[a]

Cost Components	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	Costs[b]
Draft WM PEIS Regionalized 2 Alternative Site Costs								
INEL/ANL-W	$125	$549	$875	$493	$930	$1,023	$90	$2,042
Hanford	$187	$679	$1,241	$384	$584	$1,813	$95	$2,491
SRS	$87	$327	$509	$100	$15	$982	$28	$1,023
LANL	$56	$250	$480	$245	$454	$539	$37	$1,031
RFETS	$34	$145	$303	$49	$46	$457	$29	$531
ORNL	$64	$207	$335	$72	$109	$554	$14	$678
Total	---	---	---	---	---	---	---	$7,796
SEIS-II No Action Alternative 1A Site Costs								
INEL/ANL-W	$281	$1,235	$1,969	$1,109	$2,093	$2,302	$203	$4,597
Hanford	$1,144	$4,155	$7,595	$2,350	$3,574	$11,096	$581	$15,251
SRS	$100	$376	$585	$115	$17	$1,129	$32	$1,179
LANL	$176	$788	$1,512	$772	$1,430	$1,698	$117	$3,245
RFETS	$60	$254	$530	$86	$81	$800	$51	$931
ORNL	$132	$428	$693	$149	$226	$1,147	$29	$1,401
Preliminary Discount	$42	$183	$359	$120	$134	$527	$42	$703
Total	$1,936	$7,419	$13,243	$4,700	$7,554	$698	$1,055	$27,307
Total Discounted at 4.1 Percent	$1,074	$4,114	$7,344	$2,607	$4,189	$10,369	$585	$15,143

Consolidated Site Volumes	WM PEIS CH-TRU Waste	WM PEIS RH-TRU Waste	WM PEIS Total	SEIS-II CH-TRU Waste	SEIS-II RH-TRU Waste	SEIS-II Total	Volume Adjustment Factor
INEL/ANL-W	38,000	610	38,610	86,811	0	86,811	2.25
Hanford	19,000	6,300	25,300	121,529	33,202	154,731	6.12
SRS	17,000	0	17,000	19,567	0	19,567	1.15
LANL	11,000	89	11,089	34,931	0	34,931	3.15
RFETS	6,200	0	6,200	10,862	0	10,862	1.75
ORNL	1,000	1,700	2,700	0	5,585	5,585	2.07
Total	96,970	9,039	106,009	273,700	38,787	312,486	---

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and is also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

(DOE 1995b), for information concerning mileage between sites and the fixed and variable costs per truck shipment between sites; and (2) the *Comparative Study of the Waste Isolation Pilot Plant (WIPP) Transportation Alternatives* (DOE 1994) for information concerning the shipment costs of CH-TRU waste and RH-TRU waste via regular-class rail service and dedicated-class rail service.

The number of shipments reflect potential weight, thermal power, or plutonium-239 equivalent curies (PE-Ci) limitations. These relationships are described in Appendix A of this document. Truck shipments are limited to a maximum of three TRUPACT-IIs or one RH-72B per shipment. Rail shipments (either regular-class or dedicated-class) are limited to a maximum of six TRUPACT-IIs or two RH-72Bs per rail car. CH-TRU waste shipments may include as many as 42 drums of low-density waste (three TRUPACT-IIs) or as few as 12 drums of high-density waste (two TRUPACT-IIs). For RH-TRU waste, no limitations were assumed in meeting container and shipping specifications.

Approximately 38 percent of the waste shipments for the Proposed Action and Action Alternative 1 reflect two TRUPACT-IIs per shipment (the remainder involves three TRUPACT-IIs per shipment). All of the waste shipments for Action Alternative 2 reflect two TRUPACT-IIs per shipment. Approximately 86 percent of the shipments for Action Alternative 3 involve two

Table D-8
Waste Treatment Facility Costs for No Action Alternative 1B
in Millions of 1994 Dollars[a]

Cost Components	Preoperations	Construction	Operations and Maintenance	Decontamination and Decommissioning	Retrieval and Characterization	Treatment	Storage	Costs[b]
Draft WM PEIS Regionalized 3 Alternative Site Costs								
INEL/ANL-W	$157	$680	$1,140	$508	$930	$1,456	$100	$2,485
Hanford	$187	$679	$1,241	$384	$584	$1,813	$95	$2,491
SRS	$87	$327	$509	$100	$15	$982	$28	$1,024
ORNL	$64	$207	$335	$72	$109	$554	$14	$6,678
Total	---	---	---	---	---	---	---	$6,678
SEIS-II No Action Alternative 1B Site Costs								
INEL/ANL-W	$539	$2,332	$3,910	$1,742	$3,190	$4,994	$926	$9,121
Hanford	$1,144	$4,155	$7,595	$2,350	$3,572	$11,096	$1,251	$15,911
SRS	$100	$376	$585	$115	$17	$1,129	$92	$1,239
ORNL	$132	$428	$693	$149	$226	$1,147	$69	$1,441
Preliminary Treatment	$228	$989	$1,941	$647	$723	$2,854	$228	$3,805
Total	$2,144	$8,282	$14,725	$5,003	$7,730	$21,220	$2,338	$27,711
Total Discounted at 4.1 Percent	$1,214	$4,690	$8,339	$2,834	$4,378	$12,018	$687	$17,083
Consolidated Site Volumes	**WM PEIS CH-TRU Waste**	**WM PEIS RH-TRU Waste**	**WM PEIS Total**	**SEIS-II CH-TRU Waste**	**SEIS-II RH-TRU Waste**	**SEIS-II Total**	**Volume Adjustment Factor**	
INEL/ANL-W	38,000	610	38,610	132,604	0	132,604	3.43	
Hanford	19,000	6,300	25,300	121,529	33,202	154,731	6.12	
SRS	17,000	0	17,000	19,567	0	19,567	1.15	
ORNL	1,000	1,700	2,700	0	5,585	5,585	2.07	
Total	96,970	9,039	106,009	273,700	38,787	312,486	---	

[a] Volumes and dollars have been rounded. Actual totals may differ due to rounding.
[b] "Costs" equal the sum of the costs for Preoperations, Construction, Operations and Maintenance, and Decontamination and Decommissioning and is also equal to the sum of the costs for Retrieval and Characterization, Treatment, and Storage.

TRUPACT-IIs per shipment. These percentages are based on stored waste stream data and are extrapolated to the other wastes for Action Alternatives 1 and 3.

Total shipments cover the number of shipments made from the small sites to consolidation sites for treatment and storage, and the number of shipments of treated waste volumes to WIPP. Total mileage depends on the number of shipments required to transport the treated waste volumes from each site to WIPP and the round-trip mileage between each site and WIPP. Total cost covers fixed and variable costs of transporting waste volumes between sites under the various options. Various cost parameters were used in the estimation of waste transportation costs, including the following:

- Fixed costs by truck - the number of truck shipments required in the transportation of treated waste volumes multiplied by an average fixed cost per shipment of $9,260

- Variable costs by truck - the number of round trip miles between waste origin and destination multiplied by an average variable cost of $0.12 cents per mile

- Total cost by rail (regular or dedicated rail service) - the number of rail cars shipped multiplied by a round-trip carload charge that varies from site to site, ranging from $13,880 for Rocky Flats Environmental Technology Site (RFETS), under regular rail service up to $247,314 for Hanford, under dedicated rail service

A summary of the total waste transportation costs is presented in Table D-9. Note that the transportation cost impacts for combined CH-TRU waste and RH-TRU waste shipments range from a minimum of $11 million under No Action Alternatives 1 and 2, to a maximum of $15.69 billion under Action Alternative 3, involving dedicated rail.

Table D-9
Summary of Transportation Costs by Alternative In Millions of 1994 Dollars

Action Alternative	Total Shipments	Total Mileage	Total Cost in Millions of 1994 Dollars
Proposed Action	38,290	105,608,165	$1,588
No Action Alternative 1A (Truck)	2,818	4,082,295	$74
No Action Alternative 1A (Regular Class Rail)	1,409	--	$33
No Action Alternative 1A (Dedicated Class Rail)	1,409	--	$251
No Action Alternative 1B (Truck)	7,702	14,031,655	$235
No Action Alternative 1B (Regular Class Rail)	3,851	--	$157
No Action Alternative 1B (Dedicated Class Rail)	3,851	--	$1,184
No Action Alternative 2	0	0	0
Action Alternative 1 (Truck)	107,179	334,124,688	$4,892
Action Alternative 1 (Regular Class Rail)	58,827	--	$1,550
Action Alternative 1 (Dedicated Class Rail)	58,827	--	$11,315
Action Alternative 2A (Truck)	50,076	152,252,697	$2,241
Action Alternative 2A (Regular Class Rail)	28,112	--	$723
Action Alternative 2A (Dedicated Class Rail)	28,112	--	$5,113
Action Alternative 2B (Truck)	54,958	171,085,869	$2,506
Action Alternative 2B (Regular Class Rail)	13,062	--	$547
Action Alternative 2B (Dedicated Class Rail)	13,062	--	$5,621
Action Alternative 2 (Truck)	106,397	338,038,834	$4,929
Action Alternative 2 (Regular Class Rail)	51,683	--	$1,227
Action Alternative 2 (Dedicated Class Rail)	51,683	--	$9,821
Action Alternative 3 (Truck)	149,671	465,354,452	$6,817
Action Alternative 3 (Regular Class Rail)	83,483	--	$2,236
Action Alternative 3 (Dedicated Class Rail)	83,483	--	$15,693

D.1.3 WIPP Operations Budget

The life-cycle cost of WIPP operations will depend on the period of emplacement operations, which varies across the different SEIS-II alternatives. The analysis relied on budgetary information provided by Krznarich (1996). This budgetary information projects an average annual WIPP-programmatic budget of $150 million over the period of emplacement operations and an average annual WIPP-project budget of $180 million. Life-cycle cost impacts were based on the WIPP-programmatic budget, while economic impacts in the region of influence (ROI) were based on the larger WIPP-project budget. Other budgetary items, such as federal transfer payments made to state and local government agencies involving WIPP operations, have not been considered in the analyses of Chapter 5.

The waste management facility costs, waste transportation costs and WIPP operations costs, presented in this appendix and in Chapter 5 were not discounted. The approach for discounting the value of these costs is straight-forward. In present value terms, costs incurred t-years from the present are discounted by multiplying them by the discount factor $(1/1+r)^t$, where "r" reflects an inflation-adjusted discount rate (about 5 percent). Table D-10 provides a sample of present value calculations for a 35-year period using hypothetical annual costs of $50 million, $100 million, $500 million, and $1,000 million and inflation-adjusted discount rates of 0 percent, 3 percent, and 5 percent. The present value of the cost estimates reported in this appendix and in Chapter 5 reflect the case of a zero discount rate, and thus are relatively higher than if they were discounted at either 3 percent or 5 percent.

Table D-10
Present Values of Hypothetical Annual Costs Incurred Over 35-Years

Inflation-Adjusted Discount Rate	Present Value of Annual Expenditures: $50 million for 35 years	Present Value of Annual Expenditures: $100 million for 35 years	Present Value of Annual Expenditures: $500 million for 35 years	Present Value of Annual Expenditures: $1,000 million per year for 35 years
r=0 percent	$2,000 million	$4,000 million	$18,000 million	$35,000 million
r=3 percent	$1,000 million	$2,000 million	$11,000 million	$21,000 million
r=5 percent	$800 million	$2,000 million	$8,000 million	$16,000 million

D.2 ECONOMIC IMPACTS IN THE ROI

This section discusses the methods and assumptions used in the analysis of the economic impacts which the Proposed Action and other SEIS-II alternatives may have in the ROI. Lansford et al. (1995) provides the most recent account of WIPP's economic effects on the New Mexico economy. This work provides information about the distribution of WIPP fiscal year 1994 expenditures across industrial sectors in the ROI. This information was combined with projected WIPP operating budgets to construct a regional input-output model of the ROI for the analysis of SEIS-II economic impacts. This technical approach identifies the direct and indirect economic effects that the Proposed Action and the SEIS-II alternatives would have on regional employment, income, and output of goods and services.

The regional input-output model was developed using the IMmpact analysis for PLANning (IMPLAN) regional economic modeling framework. A detailed discussion of the IMPLAN regional modeling methods can be found in MIG (1996). A summary of the assumptions and limitations of the IMPLAN model are provided below.

- IMPLAN is a non-survey, input-output model that uses an adaptation of the 538-sector national input-output transactions table, otherwise known as the "national table." The most recent national table was released by the Bureau of Economic Analysis (BEA 1995) and represents the industrial technologies in-place in 1987.

- IMPLAN is a static input-output model having fixed input-output proportions. No accounting is made for unemployed resources or excess capacity.

- IMPLAN provides the flexibility to update the 1987-level technology of any industry, as represented in the national table, to an improved representation of the technology currently being employed.

- IMPLAN reflects technology relationships that tend to be relatively stable over 10- to 15-year spans for most industries. Rapidly changing industries, such as the computer industry, are exceptions and should be evaluated in cases where they are affected by the economic impact scenario.

- IMPLAN, like other static input-output models, assumes that all resources required to satisfy an economic expansion are either immediately available within the study region or can be immediately imported.

- IMPLAN models are "initialized" by a set of data including employment, output, value-added, final demand, personal consumption expenditures, and sales (MIG 1996).

To analyze economic impacts of a particular policy option using IMPLAN, one must have knowledge of the *net* change in "final demand" purchases made within the regional economy. This information was obtained for the ROI in 1994 from Lansford et al. (1995) and projected WIPP budget estimates provided by Krznarich (1996). Based on this regional information, the IMPLAN model generated a set of economic multipliers which were applied to WIPP-related expenditures in the ROI to determine the economic impact. The estimated economic activity multiplier for the ROI is 2.80, meaning that for each dollar of WIPP-related budget expenditure in the ROI, an additional $1.80 is generated the ROI economy. The estimated ROI employment multiplier for direct WIPP employment is 3.08, meaning that for each direct WIPP job, an additional 2.08 ROI jobs are created (these may be full- or part-time jobs). The estimated ROI labor income (employment compensation) multiplier is 2.33, meaning that for each dollar of WIPP-related income generated in the ROI, another $1.33 of additional income is generated in the ROI.

The continued operation of WIPP at the anticipated funding levels would continue to have a stabilizing effect in the ROI economy, which has historically varied according to price trends in the oil and gas industry. It is important to note, however, that the SEIS-II alternatives call for project life spans that reach as far as the year 2310, including the institutional control period. The models used to develop economic impact information are valid for application over perhaps a 10- to 15-year period. Long term economic forecasting models may be applicable for a 20-50 year period. No model exists that can be reliably applied to extremely long-term planning horizons (50 to 300+ years). The only claim that can be made with these impact estimates is that they are estimated with documented methods that are consistent across the alternatives, thus allowing a relative comparison.

The closure of WIPP presents the most noticeable economic impact in the ROI. This event is reflected in No Action Alternatives 1 and 2. These alternatives specify that, beginning in 1998, the WIPP will begin a 10-year period of decommissioning. By the year 2008, the site will be fully dismantled and returned to near-original condition with no TRU waste disposal activities having taken place. This implies that federal budget support of WIPP will be ramping down from current levels to near zero by the year 2008. This budgetary impact on the ROI can be considered in one of two ways. Under one scenario, the WIPP site can be assumed to undergo a "straight-line" decommissioning period, meaning that budgets would be cut by equal increments over the period until the site is permanently closed in the year 2008. Alternatively, WIPP closure could involve a

"front-loaded" decommissioning period where more than half of the WIPP work force would be released in the first three years and thereafter decline at a much slower rate over the remaining years. The workforce would be declining rapidly and at the same time convert from an operations workforce to a decommissioning workforce until permanent closure in the year 2008.

The economic impacts reported in Chapter 5 are based on the straight-line decommissioning assumption. Corresponding to this case, the flow of federal dollars for WIPP salaries and expenditures in the ROI would decline steadily for 10 years prior to permanent closure of the facility. The decline in direct WIPP-related business would translate into additional declines in employment and salaries in the ROI workforce and industries that supply WIPP-related goods and services. Less of the support services currently provided in the ROI would remain viable over the course of WIPP closure. Similarly, the ROI service sector will decline as individuals leave the region in search of employment opportunities. At the same time, local and state government agencies would be affected by reductions in sales tax revenue and the region's tax base. Finally, the reduction in federal payments to government agencies in the ROI for WIPP-related services would have an affect on road and highway improvements, emergency preparedness, and other public services currently provided in the ROI. These impacts are not included in the analyses of Chapter 5.

D.3 REFERENCES CITED IN APPENDIX D

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APPENDIX E

APPENDIX E
TRANSPORTATION

This appendix supports results of transportation analyses presented in Chapter 5 of this document. Plans for transporting transuranic (TRU) waste to the Waste Isolation Pilot Plant (WIPP) and the impacts associated with that transportation are discussed.

E.1 INTRODUCTION

Since the Department of Energy (DOE or the Department) prepared the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) in 1990, new information has become available concerning the Department's TRU waste and its management. This new information falls into several categories, namely:

- ***Waste characterization:*** Due to improved site waste characterization, the volume and characteristics of waste to be transported are better understood than was the case for SEIS-I. The improved data permits more thorough analyses of the impacts associated with transporting TRU waste. Additionally, site-specific waste characterization data have been examined thoroughly to ensure that each site would meet all of the required shipping limits; including weight, volume, curie, and thermal power limits.

- ***The addition of small quantity sites under the Proposed Action and the alternatives:*** Additional sites with small quantities of TRU waste and sites with additional sources of TRU waste (previously disposed of, polychlorinated biphenyl (PCB)-commingled, commercial, and nondefense) have been added to the analyses, and the impacts of transporting waste from these sites have now been considered. Currently, DOE intends for these small quantity sites to ship their TRU waste to one of the larger quantity sites for processing. The locations of the larger quantity sites, or treatment sites, would be based upon the centralized, decentralized, and regionalized alternatives presented in the *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS) (DOE 1995b).

- ***Waste treatment agreements:*** To date, DOE has submitted Federal Facility Compliance Act (FFCAct) site treatment plans for its treatment sites, and orders or settlements have been reached with affected states and the U.S. Environmental Protection Agency (EPA). In most cases, TRU waste would be retrieved, characterized, treated, certified to meet the WIPP Waste Acceptance Criteria (WAC), and then stored pending disposal. Some of the smaller sites would ship TRU waste to another DOE site for characterization, treatment, certification to meet WAC, and then storage. As a possible exception, DOE has reached a negotiated settlement with the State of Idaho that would allow DOE to procure, construct, and operate a mixed waste treatment facility. It is currently planned that this mixed waste treatment facility would use a thermal process that would result in a waste form that would meet Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions (LDR). Treated waste would also meet WAC. Additional information regarding the management of TRU waste in the DOE complex may be found in the Draft WM PEIS.

- ***Route changes:*** There have been changes on the routes to WIPP coming from Argonne National Laboratory - East (ANL-E), the Mound Plant (Mound), Lawrence Livermore National Laboratory (LLNL), and Oak Ridge National Laboratory (ORNL). These routes, with the exception of the LLNL route, which was modified to bypass Los Angeles, California, now feed into Interstate-20 and enter New Mexico from the south. No waste, therefore, would travel on Interstate-40 from the east into New Mexico. Additionally, minor changes in some of the routes surrounding the major generator-storage sites have been decided upon and potential bypass routes around Santa Fe, New Mexico; Roswell, New Mexico; and Carlsbad, New Mexico are under consideration.

- ***HIGHWAY and INTERLINE codes updated with 1990 census data:*** The HIGHWAY (Johnson et al. 1993a) and INTERLINE (Johnson et al. 1993b) computer codes allow for flexibility in calculating highway/rail mileage and population statistics, respectively. Each code provides mileage and population densities for designated highway and rail routes and have been updated with the most current (1990) census data.

- ***RH-72B shipping cask:*** The RH-72B shipping cask was referred to as the NUPAC in SEIS-I. Testing on the NUPAC was done on a 5/8 scale model, identified as the NUPAC 125B. Shipping canisters would be placed within the cask for added shielding and stabilization. Currently, the RH-72B shipping canister has been approved by the Nuclear Regulatory Commission (NRC). The Safety Analysis Report for Packaging application for the RH-72B shipping cask is to be submitted to the NRC in September of 1996.

Four types of impacts were assessed in this SEIS-II regarding the transportation of TRU waste to WIPP. The first was the number of traffic accidents, fatalities, and injuries likely to occur as a result of transporting TRUPACT-IIs and RH-72B casks round trip between WIPP and the generator-storage sites. The second type, accident-free radiological impacts, would be associated with the external radiation present around a TRU waste package as it is being shipped. This radiation exposes the general public and transportation workers to very low levels of radiation both during transportation and while a shipment is stopped. The third type of impact, pollution health effects, would be the result of vehicle emissions (diesel exhaust) while traveling through urban areas. The final impact would be associated with accidents that are severe enough to breach the TRU waste packages, releasing some of the radioactive and hazardous material being shipped. For these accidents, two sets of radionuclide inventories were developed for both contact-handled (CH) TRU and remote-handled (RH) TRU waste shipments. The first inventory was based upon limits presented in planning-basis WAC (DOE 1996) and the second inventory was based upon site-average radionuclide inventories.

Each type of impact presented in this appendix depends upon the route characteristics, the number of shipments via each route; and, for accidents, the accident environment associated with a particular mode of transportation and the behavior of the waste form and packaging in that environment. Thus, this section will summarize important route characteristics, TRU waste shipments using each route, and the impacts of potential transportation accidents.

Table 3-17 of Chapter 3 presents the features of the Proposed Action and the alternatives that are critical to transportation impact analyses, including the consolidation and treatment of TRU waste and TRU waste emplacement time frames. For a comprehensive description of the TRU waste transportation system, the reader is referred to Appendix A of this document and Appendices C, L, and M of SEIS-I (DOE 1990). Appendix L describes the design, testing, and certification of the

shipping containers and casks used for TRU waste; Appendix C describes emergency-response training and capabilities; and Appendix M describes the management plan of the carrier.

E.2 TRANSPORTATION MODES

In following subsections, the modes of transportation are discussed.

E.2.1 Truck Transportation and Highway Routes

Although WIPP has facilities designed to receive TRU waste shipments either by truck or by rail, the Proposed Action considers shipment only by truck. Under the action alternatives, TRU waste transportation by truck is analyzed, and those results are used to assess the transportation impacts associated with shipments by rail.

To ensure that transportation operations proceed safely and efficiently, DOE has developed operating plans and provided communications facilities, including a dual satellite-based vehicle tracking system. DOE has awarded a contract to CAST Transportation, herein referred to as the "carrier." This contract, which runs for one year with options for four 1-year extensions, contains provisions for the safe and efficient transport of TRU waste and for responses to transportation emergencies. One of the contract provisions requires that the carrier prepare a management plan. The carrier's plan has been prepared and is similar to the plan discussed in Appendix M of SEIS-I (DOE 1990). Key provisions of the contract include the following:

- The carrier will provide tractors and drivers which are dedicated to contract requirements. Drivers are to be technically qualified and experienced and must complete training in twenty-eight training categories, including hazardous and radioactive materials transportation. Tractors are to be domiciled and maintained within 80 kilometers (50 miles) of WIPP. Tractors will be dispatched with a DOE-owned trailer and empty shipping containers.

- DOE will operate a transportation operations control center, the Central Monitoring Room (CMR), 24 hours per day, 7 days per week. This center will maintain day-to-day contact with the carrier and drivers. As required by DOE Order 460.2, the Transportation Tracking and Communications System (TRANSCOM) Control Center located in Oak Ridge, Tennessee, has the ability to track and communicate with shipment vehicles using the DOE TRANSCOM system. Tracking information can be disseminated to DOE users and other stakeholders, as necessary.

- The carrier will be required to meet federal regulatory requirements for the transportation of radioactive and hazardous materials, including: driver training in accordance with Title 49 of the Code of Federal Regulations (CFR), Part 172 (49 CFR 172), Subpart G entitled "Emergency Response Information"; 49 CFR Part 177.825 entitled "Routing and Training Requirements for Class 7 (Radioactive) Materials; 49 CFR Part 391 entitled "Qualifications of Drivers"; 49 CFR 397, Subpart D entitled "Routing of Class 7 (Radioactive) Materials"; the Commercial Motor Vehicle Safety Act of 1986 and subsequent amendments; and manifesting requirements for mixed waste specified in 40 CFR.

- The carrier is required to comply with emergency response guidelines for hazardous material and hazardous waste transporters outlined in the *Emergency Planning, Response, and Recovery Roles and Responsibilities for TRU Waste Transportation Accidents* (DOE 1995a).

In the event of an accident, carrier drivers would notify emergency first-responders via cellular phone and the CMR at WIPP via TRANSCOM. A senior DOE official and/or the DOE Carlsbad Area Office (CAO) Incident/Accident Team Leader would assist the state-provided on-scene commander. DOE resources would be made available to local authorities, as appropriate, to support the mitigation of the accident; including, but not limited to, package recovery and site cleanup. In the event of an accident such as a fire, breach, release, or suspected radioactive contamination, the carrier would follow established procedures for obtaining any needed federal, state, or local assistance and technical advice.

Drivers would carry instructions regarding the appropriate actions to be taken in the event of an accident and would be trained in packaging recovery procedures. In addition, the TRANSCOM system provides an electronic version of the U.S. Department of Transportation (DOT) Emergency Response Guidebook information, which is specific to each shipment material, to all TRANSCOM users. According to 49 CFR Part 390.15(b), the carrier shall maintain a register containing information on the accident for a period of one year after the accident occurs. Any carrier accident, no matter how minor, would be reported to the CAO Transportation Manager, the WIPP Traffic Manager, the CMR operator, and DOE Headquarters (HQ) Emergency Operations Center (EOC) via the DOE Albuquerque Operations Office. If not already notified by the carrier, the CMR operator would notify the shipper.

The carrier's management plan provides procedures to be followed regarding adverse weather conditions, delays, and parking during TRU waste shipments. Weather conditions would be constantly monitored, and drivers would be alerted to possible severe weather conditions. Delays may occur as the result of problems at the sites, weather conditions, or maintenance checks. Schedule delays of two or more hours from the shipping, receiving, and transit time would be immediately reported to the CMR, which would then notify the shipper or receiver, as appropriate. There would be no

TRANSCOM SYSTEM

DOE has developed a transportation tracking and communications system that is used to track truck and rail shipments. This satellite-based system, the TRANSCOM System, has been in operation since 1989. Since its inception, the TRANSCOM System has tracked over 500 shipments for DOE. The use of TRANSCOM is mandated by DOE Order 460.2, *Departmental Materials Transportation and Packaging Management*.

The mission of the TRANSCOM System is to provide tracking and communications for shipments of radioactive materials, hazardous materials, and other high-visibility shipping campaigns, as specified by DOE. The TRANSCOM System is managed and operated at the TRANSCOM Control Center (TCC) in Oak Ridge, Tennessee, for DOE.

The TRANSCOM System provides the TCC staff, shippers, carriers, receivers, and state, Tribal, and federal users with the ability to view information about shipments and communicate with each other during shipment tracking. Information about shipment contents, points of contact, routes, status, locations, and emergency response information is available to local emergency response teams and each user. The information is displayed in tabular and graphical form using a series of national, state, and county maps. The vehicle location can be determined to within a few meters, with position updates as frequently as every 60 seconds. Drivers are alerted to adverse weather or road conditions.

"deadlines" for a shipment to be received at WIPP. If a shipment were delayed, a new scheduled time of arrival would be arranged.

The carrier's management plan follows instructions provided by the Western Governor's Association and DOE regarding the selection of suitable site parking areas. In the event of a shipping layover, carriers would use designated DOE or Department of Defense parking sites or an area designated by the affected state as a safe parking area. If a designated site were not available, the driver would select an appropriate site based on criteria such as nearby population, access, and security. The driver would also notify the nearest state police district office to confirm the appropriateness of the location. Motor vehicles transporting hazardous waste material other than Class A or Class B explosives are required not to be parked on or within 1.5 meters (5 feet) of the traveled portion of a public street or road, except for brief periods when the necessities of operation make it impracticable to park in any other place.

E.2.1.1 HIGHWAY Code

The HIGHWAY computer code (Johnson et al. 1993a) was used to determine the various truck routes used for these analyses. HIGHWAY is a computerized road atlas that details more than 386,000 kilometers (240,000 miles) of interstate and other highways. The user can specify the routing criteria to constrain the route selection. HIGHWAY calculates the total route length and the distances traveled through rural, suburban, and urban population zones. The HIGHWAY model contains an HM-164 and a WIPP default routing option. The HM-164 option, when activated, specifies a route that would comply with DOT regulations for highway route-controlled quantities (HRCQ) of radioactive material. The WIPP default routing option provides the New Mexico-specified routes to WIPP and uses routes defined by the HM-164 option for routes outside of New Mexico. When determining the route selection for the transportation analyses, the default settings were used in most cases, and the WIPP routing code option was activated. In this way, the most direct route that complies with DOT regulations would be selected by HIGHWAY. Population densities along each route were derived from 1990 census data. Rural, suburban, and urban areas are characterized according to the following breakdown:

- Rural mean population density of 6 persons per square kilometer (16 per square mile)
- Suburban mean population density of 719 persons per square kilometer (1,863 per square mile)
- Urban mean population density of 3,861 persons per square kilometer (10,003 per square mile)

E.2.1.2 Regulations Applicable to Highway Route Selection

On behalf of the carrier, DOE has coordinated shipping routes with the affected states. As a matter of policy, DOE has determined that all shipments, whether or not the definition of HRCQ has been met, will use the preferred routes in 49 CFR Part 173.403(l). Preferred routes consist of interstate-system highways, interstate bypasses or beltways around cities, and state-designated routes. This routing rule permits states and Indian tribes to designate routes in accordance with DOT guidelines or equivalent routing analysis. Interstate highways must be used in the absence of routes designated by states or tribes, unless a deviation is necessary.

State-designated routes are preferred routes, selected in accordance with DOT guidelines (49 CFR Part 397.101[b] and [c]) or an equivalent routing analysis which adequately considers the overall impact to the public. The designation of routes must be preceded by substantive consultation with affected local jurisdictions and with any other states along such routes to ensure the consideration of impacts and the continuity of designated routes.

A state routing agency is an entity that is authorized to use a state legal process pursuant to 49 CFR 397, Subpart D to impose routing requirements, enforceable by state agencies, on carriers of radioactive material without regard to intrastate jurisdictional boundaries. This would include a common agency of more than one state such as one established by interstate compact. This term also includes Indian tribal authorities with police power to regulate and enforce highway routing requirements within their lands.

DOT regulations in 49 CFR 397, Subpart D provide routing and training requirements for carriers of radioactive material to ensure that the vehicles used for such transportation operate on routes that would minimize potential radiological impacts. Deviations from the state-designated route are allowed for necessary rest, fuel, and vehicle repair stops; to pick up, deliver, or transfer radioactive materials; and for emergency conditions that would make continued use of the preferred route unsafe. As required by 49 CFR Part 397.101(g), the carrier must prepare a route plan and supply a copy of the plan to the Federal Highway Administration, Traffic Control Division, the driver, and the shipper. Any deviation from the preferred route, and the reason for it, must be reported in an amendment to the route plan within thirty days following the shipment.

E.2.1.3 Proposed Routes

The proposed routes for transporting TRU waste by truck, as determined using HIGHWAY, are shown in Figure E-1. Figure E-2 details the routes through New Mexico. For the purposes of SEIS-II analyses, routes were selected based on the preferred routes defined in 49 CFR Part 173.403(l) and to be consistent with existing routing practices and applicable routing regulations and guidelines. These routes may not be the actual routes that would be used to transport TRU waste in the future. Details on the routes through New Mexico and from the 10 sites with the greatest number of shipments of waste to WIPP are presented below.

Routes through the State of New Mexico. As shown in Figure E-1, all transportation routes converge in New Mexico. Transportation and routing have been identified in several agreements with the State of New Mexico. The agreements recognize that movements between interstate highways and WIPP would involve local highways, and because New Mexico is the host state, these highways would have a relatively concentrated service. Therefore, DOE agreed to support the state in efforts to obtain congressional funds necessary to repair and upgrade designated highway segments.

Route from Mound, Ohio. The proposed route is as follows:

Local Road to State 725, in Miamisburg, OH, 1.6 kilometers (1 mile)
State 725 to I-75, near Miamisburg, OH, 5 kilometers (3 miles)
I-75 to I-70, near Vandalia, OH, 29 kilometers (18 miles)
I-70 to I-465, southeast of Indianapolis, IN, 172 kilometers (107 miles)
I-465 to I-70, southwest of Indianapolis, IN, 32 kilometers (20 miles)
I-70 to I 57, near Teutopolis, IL, 211 kilometers (131 miles)
I-57 to I-55, near Sikeston, MO, 290 kilometers (180 miles)

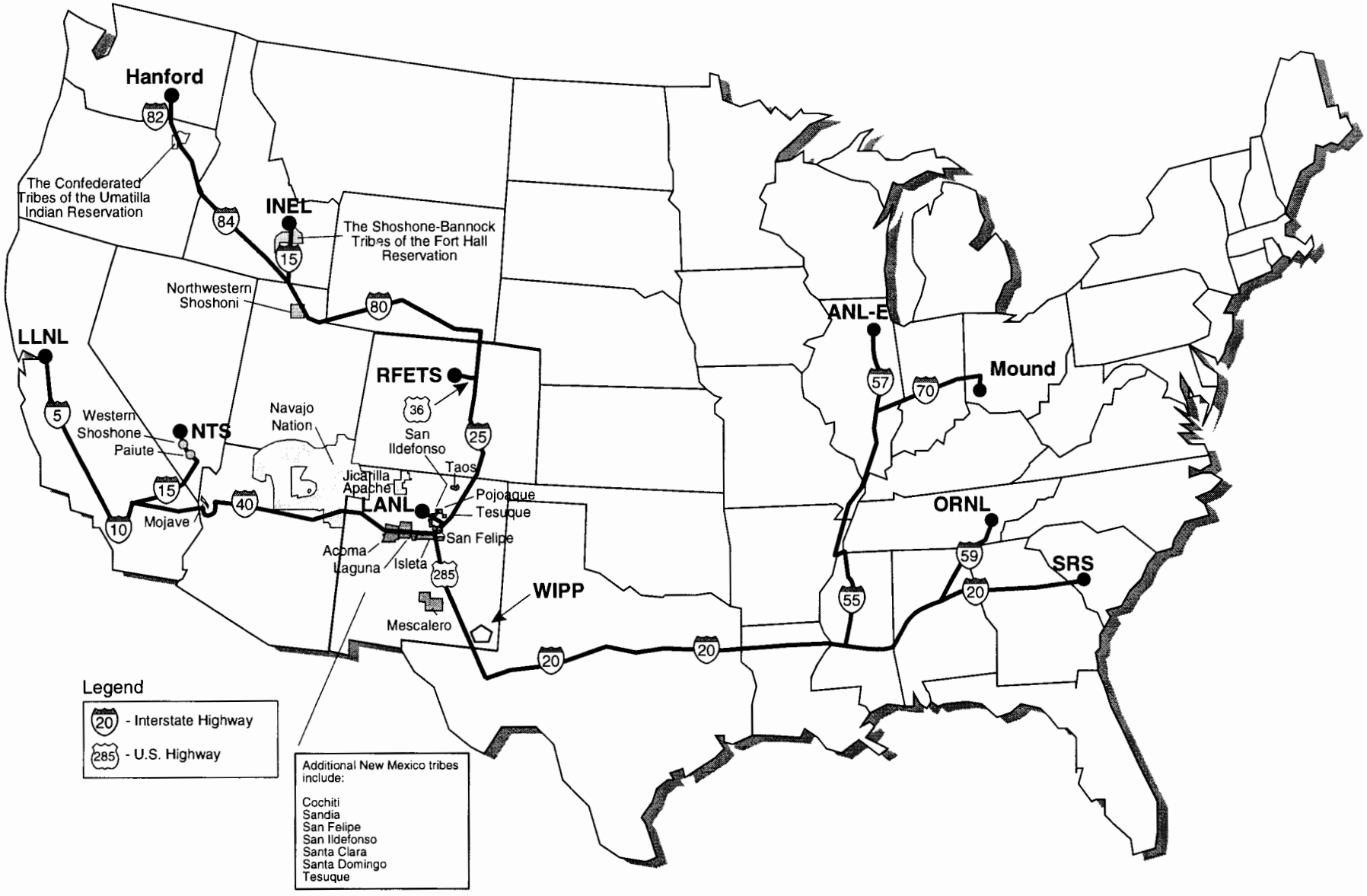

Figure E-1
Proposed TRU Waste Truck Transportation Routes on U.S. and Interstate Highways

Figure E-2
Proposed TRU Waste Truck Transportation Routes in New Mexico

I-55 to I-220, north of Jackson, MS, 541 kilometers (336 miles)
I-220 to I-20, west of Jackson, MS, 18 kilometers (11 miles)
I-20 to I-220, east of Shreveport, LA, 328 kilometers (204 miles)
I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)
I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
US-285 to US 180/62, at Carlsbad, NM, 137 kilometers (85 miles)
US 180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from ANL-E, Illinois. The proposed route is as follows:

Cass Avenue to I-55, north of ANL-E, 1.6 kilometers (1 mile)
I-55 to I-294, southwest of Chicago, IL, 8 kilometers (5 miles)
I-294 to I-80, south of Chicago, IL, 29 kilometers (18 miles)
I-80 to I-57, near Tinley Park, 8 kilometers (35 miles)
I-57 to I-55, near Sikeston, MO, 592 kilometers (368 miles)
I-55 to I-220, north of Jackson, MS, 541 kilometers (336 miles)
I-220 to I-20, west of Jackson, MS, 18 kilometers (11 miles)
I-20 to I-220, east of Shreveport, LA, 328 kilometers (204 miles)
I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)
I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
US-285 to US 180/62, at Carlsbad, NM, 137 kilometers (85 miles)
US 180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from ORNL, Tennessee. The proposed route is as follows:

Bethel Valley Road to State 95, west of ORNL, 3 kilometers (2 miles)
State 95 to I-40, south of Oak Ridge, TN, 5 kilometers (3 miles)
I-40 to I-75, southwest of Knoxville, TN, 6 kilometers (4 miles)
I-75 to I-24, east of Chattanooga, TN, 133 kilometers (83 miles)
I-24 to I-59, southwest of Chattanooga, TN, 31 kilometers (19 miles)
I-59 to I-459, northeast of Birmingham, AL, 195 kilometers (121 miles)
I-459 to I-20, southwest of Birmingham, AL, 53 kilometers (33 miles)
I-20 to I-220, east of Shreveport, LA, 684 kilometers (425 miles)
I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)
I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
US-285 to US-180/62, at Carlsbad, NM, 137 kilometers (85 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Savannah River Site (SRS), South Carolina. The proposed route is as follows:

SRS access road to State 19, north of SRS, 14 kilometers (9 miles)
State 19 to I-20, north of Aiken, SC, 29 kilometers (18 miles)
I-20 to I-285, east of Atlanta, GA, 249 kilometers (155 miles)
I-285 to I-20, around the south side of metro Atlanta, 45 kilometers (28 miles)
I-20 to I-459, northeast of Birmingham, AL, 204 kilometers (127 miles)
I-459 to I-20, southwest of Birmingham, AL, 47 kilometers (29 miles)
I-20 to I-220, east of Shreveport, LA, 684 kilometers (425 miles)
I-220 to I-20, around the north side of Shreveport, LA, 29 kilometers (18 miles)

I-20 to US-285, at Pecos, TX, 978 kilometers (608 miles)
US-285 to US-180/62, at Carlsbad, NM, 137 kilometers (85 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Hanford Site (Hanford), Washington. The proposed route is as follows:

Route 4S to State 240, in Hanford Reservation, 6 kilometers (4 miles)
State 240 to I-182, in Richland, WA, 11 kilometers (7 miles)
I-182 to I-82, southwest of Richland, WA, 8 kilometers (5 miles)
I-82 to I-84, near Hermiston, OR, 66 kilometers (41 miles)
I-84 to I-80, near Echo, UT, 949 kilometers (590 miles)
I-80 to I-25, at Cheyenne, WY, 626 kilometers (389 miles)
I-25 to US-285, southeast of Santa Fe (near Lamy), 767 kilometers (477 miles)
US-285 to US-180/62, at Carlsbad, NM, 414 kilometers (257 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Idaho National Engineering Laboratory (INEL), Idaho. The proposed route is as follows:

Plant Road to US-26, on INEL Reservation, 1.6 kilometers (1 mile)
US-26 to I-15, near Blackfoot, ID, 64 kilometers (40 miles)
I-15 to I-84, southwest of Ogden, UT, 243 kilometers (151 miles)
I-84 to I-80, near Echo, UT, 63 kilometers (39 miles)
I-80 to I-25, at Cheyenne, WY, 626 kilometers (389 miles)
I-25 to US-285, southeast of Santa Fe (near Lamy), 767 kilometers (477 miles)
US-285 to US-180/62, at Carlsbad, NM, 414 kilometers (257 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Rocky Flats Environmental Technology Site (RFETS), Colorado. The proposed route is as follows:

Rocky Flats Access Road to State 93, west of RFETS, 3 kilometers (2 miles)
State 93 to State 128, south of Boulder, CO, 5 kilometers (3 miles)
State 128 to US-36, near Broomfield, CO, 13 kilometers (8 miles)
US-36 to I-25, north of Denver, CO, 14 kilometers (9 miles)
I-25 to US-285, southeast of Santa Fe (near Lamy), 767 kilometers (477 miles)
US-285 to US-180/62, at Carlsbad, NM, 414 kilometers (257 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Los Alamos National Laboratory (LANL), New Mexico. The proposed route is as follows:

Los Alamos Truck Route to State 4, east of Los Alamos, 10 kilometers (6 miles)
State 4 to State 502, east of Los Alamos, NM, 1.6 kilometers (1 mile)
State 502 to US-84, at Pojoaque, NM, 19 kilometers (12 miles)
US 84 to I-25, south of Santa Fe, NM, 32 kilometers (20 miles)
I-25 to US-285, southeast of Santa Fe (near Lamy), 13 kilometers (8 miles)
US-285 to US-180/62, at Carlsbad, NM, 414 kilometers (257 miles)

US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from LLNL, California. The proposed route is as follows:

Local Road to I-580, northeast of Livermore, CA, 5 kilometers (3 miles)
I-580 to I-5, near Vernalis, CA, 39 kilometers (24 miles)
I-5 to I-210, north of Los Angeles, CA, 468 kilometers (291 miles)
I-210 to I-10, near Pomona, CA, 77 kilometers (48 miles)
I-10 to I-15, in Ontario, CA, 27 kilometers (17 miles)
I-15 to I-40, in Barstow, CA, 119 kilometers (74 miles)
I-40 to US-285, near Clines Corner, NM, 1,191 kilometers (740 miles)
US-285 to US-180/62, at Carlsbad, NM, 349 kilometers (217 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP North Access Road to WIPP, 18 kilometers (11 miles)

Route from Nevada Test Site (NTS), Nevada. The proposed route, which is currently being renegotiated with the state, is as follows:

Local Road to US-95, south of Mercury, NV, 10 kilometers (6 miles)
US-95 to State Road 373, near Amargon Valley, NV, 39 kilometers (24 miles)
State Road 373 to State Road 127, near Shosone, CA, 81 kilometers (50 miles)
State Road 127 to I-15, near Baker, CA, 90 kilometers (56 miles)
I-15 to I-15, in Barstow, CA, 101 kilometers (63 miles)
I-40 to US-285, near Clines Corner, NM, 1,191 kilometers (740 miles)
US-285 to US-180/62, at Carlsbad, NM, 349 kilometers (217 miles)
US-180/62 to WIPP North Access Road, 43 kilometers (27 miles)
WIPP Access Road to WIPP, 18 kilometers (11 miles)

E.3 ACCIDENTS, INJURIES, FATALITIES AND POLLUTION-RELATED HEALTH EFFECTS

This section addresses the impacts of traffic accidents and vehicle emissions associated with transporting TRU waste to WIPP. These impacts are not related to the radioactive material or hazardous chemicals being transported and would be the same as the impacts resulting from the transportation of nonhazardous material. Accident impacts were calculated as the number of injuries and fatalities that would be expected due to additional truck traffic along the proposed routes, and were calculated on a per-shipment basis, then totaled for all shipments over the transportation period. Calculations were based on data presented in *Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight* (Saricks and Kvitek 1994). These data, route mileages, and the number of shipments along each route were used to determine the aggregate impacts from transporting TRU waste. Impacts from vehicle emissions (pollution-related health effects) were calculated as the number of excess latent cancer fatalities (LCF) in the exposed population due to truck exhaust emissions.

All of the analyses were based on the impact-per-shipment from the major generator-storage sites to WIPP. Results were adjusted to account for small quantity site shipments to the major generator-storage sites (see Section E.6).

E.3.1 Methods of Analyses

Whenever material is shipped, the possibility of a traffic accident which could result in vehicular damage, injury, or death exists. Even when drivers are trained in defensive driving and take great care, there is a risk of a traffic accident. To date, shipments of empty TRUPACT-IIs have logged more than 1,529,000 kilometers (950,000 miles) without accident. However, for the SEIS-II analyses, truck accident statistics that were compiled for each state by highway type were used (Saricks and Kvitek 1994). No assumption was made that carrier drivers would be better trained or would be more careful than other truck drivers on the nation's roads.

It is important to note that the accident rates used in this assessment were computed using all interstate shipments, regardless of the cargo. Saricks and Kvitek (1994) point out that shippers and carriers of radioactive material generally have a higher-than-average awareness of transportation impacts and prepare for such shipments accordingly. Still, these effects were not considered. Separate accident rates for travel in rural, suburban, and urban population density zones in each state were used. The total accident impact for a case, therefore, depends on the total distance traveled in the various population zones within each state and does not rely on national-average accident statistics.

As discussed in Appendix A, the volumes of waste that are currently in storage and projected to be generated through the year 2033 were estimated from information provided in the *Transuranic Waste Baseline Inventory Report, Revision 2* (BIR-2) (DOE 1995d). Using the methods discussed in Appendix A, the volumes of CH-TRU and RH-TRU waste transported under the Proposed Action and each alternative were calculated. Also, the number of shipments needed to transport this waste were calculated on a site-by-site basis.

For truck shipments, it was assumed that CH-TRU waste would be packaged in Type A 55-gallon drums and transported in TRUPACT-IIs. Each TRUPACT-II would carry a maximum of two 7-packs of drums, and each shipment could carry two or three TRUPACT-II containers, a maximum of 42 drums per shipment. The number of drums per TRUPACT-II would vary depending on waste restrictions. These restrictions include limits on weight, volume, thermal power, plutonium-239 equivalent curies (PE-Ci), and fissile gram equivalents. It was assumed that RH-TRU waste would be transported in RH-72B casks, with only one cask per shipment. The number of CH-TRU and RH-TRU waste shipments to WIPP under the Proposed Action and the action alternatives are shown in Tables E-1 and E-2, respectively. Shipments under No Action Alternative 1 reflect the number of shipments needed to consolidate TRU waste at treatment sites. TRU waste is not shipped to WIPP under this alternative.

Under the Proposed Action and the action alternatives, there would be shipments from the small quantity sites to some of the 10 major generator-storage sites to consolidate waste prior to shipment to WIPP. These small quantity sites and the number of shipments are presented in Table E-3. Since none of the sites presented in Table E-3 would treat their waste before shipment, the number of shipments would be the same under the Proposed Action and the action alternatives. Under Action Alternatives 2 and 3, and No Action Alternative 1, some of the ten major generator-storage sites would ship their waste to one of the other major sites prior to shipment to WIPP for consolidation or treatment. These shipment numbers are presented in Table E-4.

The HIGHWAY code was used to estimate the mileages from the various sites to WIPP and to estimate the corresponding population density fractions. Additionally, mileages from the small quantity sites to the major generator sites were determined using HIGHWAY. The TRU waste

Table E-1
Number of Shipments for CH-TRU Waste

Waste Origin Site	Proposed Action Scaled to WIPP Max.	Action Alternative 1			Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Argonne National Laboratory - East	28	24	---	24	---	---	---	---	---	---	22	---	22
Hanford Site	13,666	11,562	7,167	18,729	8,219	2,543	10,762	8,219	2,543	10,762	11,562	7,194	18,756
Idaho National Engineering Laboratory Argonne National Laboratory-West	5,782	4,892	6,474	11,366	4,178	3,586	7,764	8,234	4,142	12,376	4,892	6,639	11,531
Lawrence Livermore National Laboratory	162	137	---	137	---	---	---	---	---	---	137	---	137
Los Alamos National Laboratory	5,009	4,238	1,590	5,828	2,952	557	3,509	---	---	---	4,236	1,590	5,826
Mound Plant	59	50	23	73	---	---	---	---	---	---	50	3	53
Nevada Test Site	86	73	---	73	---	---	---	---	---	---	73	---	73
Oak Ridge National Laboratory	251	212	8	220	---	---	---	---	---	---	192	8	200
Rocky Flats Environmental Technology Site	2,485	2,102	---	2,102	1,105	---	1,105	---	---	---	2,102	---	2,102
Savannah River Site	2,238	1,893	558	2,451	2,015	208	2,223	2,015	208	2,223	1,893	558	2,451
Total	**29,766**	**25,183**	**15,820**	**41,003**	**18,469**	**6,894**	**25,363`**	**18,468**	**6,893**	**25,361**	**25,159**	**15,992**	**41,151**

Table E-1
Number of Shipments for CH-TRU Waste-Continued

Waste Origin Site	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Argonne National Laboratory - East	---	---	---	22	---	22	22	---	22
Hanford Site	24,531	8,600	33,131	---	---	---	---	---	---
Idaho National Engineering Laboratory Argonne National Laboratory-West	10,386	7,769	18,155	---	---	---	---	---	---
Lawrence Livermore National Laboratory	---	---	---	137	---	137	137	---	137
Los Alamos National Laboratory	7,628	1,907	9,535	---	---	---	4,236	1,590	5,826
Mound Plant	---	---	---	50	3	53	50	3	53
Nevada Test Site	---	---	---	73	---	73	73	---	73
Oak Ridge National Laboratory	---	---	---	192	8	200	192	8	200
Rocky Flats Environmental Technology Site	2,897	---	2,897	---	---	---	2,102	---	2,102
Savannah River Site	2,885	706	3,591	---	---	---	---	---	---
Total	**48,327**	**18,982**	**67,309**	**474**	**5**	**485**	**6,812**	**562**	**8,413**

Note: Shipments for No Action Alternatives 1A and 1B are the number of shipments to consolidate TRU waste from large generator sites to treatment sites. No TRU waste would be shipped to WIPP.

Table E-2
Number of Shipments for RH-TRU Waste

Waste Origin Site	Proposed Action	Alternative 1			Alternative 2A			Alternative 2B			Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Hanford Site	3,178	47,156	1,651	48,807	17,730	1,031	18,761	17,730	1,031	18,761	17,730	1,031	18,761
Idaho National Engineering Laboratory/Argonne National Laboratory-West	3,136	3,136	711	3,847	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	367	367	190	557	---	---	---	---	---	---	---	---	---
Oak Ridge National Laboratory	1,276	5,875	3,076	8,951	2,057	1,077	3,134	2,057	1,077	3,134	2,057	1,077	3,134
Total	**7,957**	**56,534**	**5,628**	**62,162**	**19,787**	**2,108**	**21,895**	**19,787**	**2,108**	**21,895**	**19,787**	**2,108**	**21,895**

Table E-2
Number of Shipments for RH-TRU Waste-Continued

Waste Origin Site	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
Hanford Site	60,789	3,076	63,865	---	---	---	---	---	---
Idaho National Engineering Laboratory/ Argonne National Laboratory-West	---	---	---	1,098	387	1,485	1,098	387	1,485
Los Alamos National Laboratory	---	---	---	129	67	196	129	67	196
Oak Ridge National Laboratory	7,050	3,691	10,741	---	---	---	---	---	---
Total	**67,839**	**6,767**	**74,606**	**1,227**	**454**	**1,681**	**1,227**	**454**	**1,681**

Note: Shipments for No Action Alternatives 1A and 1B are the number of shipments to consolidate TRU waste from large generator sites to treatment sites. No TRU waste would be shipped to WIPP.

Table E-3
Number of CH-TRU and RH-TRU Waste Shipments to Consolidation/Treatment Sites from Sites with Smaller Quantities of TRU Waste

Origin Site with Smaller Quantities of Waste	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste			
Ames Laboratory	1	0	1
ARCO	0	1	1
Bettis Atomic Power Laboratory	20	0	20
Energy Technology Engineering Center	1	0	1
Lawrence Berkeley Laboratory	0	1	1
Pantex Plant	1	0	1
Paducah Gaseous Diffusion Plant	1	0	1
Sandia National Laboratories	2	1	3
Teledyne Brown Engineering	1	0	1
University of Missouri	1	0	1
USAMC	1	0	1
West Valley Demonstration Project	0	23	23
Total	29	26	55
RH-TRU Waste			
Battelle Columbus Laboratory	326	0	326
Bettis Atomic Power Laboratory	6	0	6
Energy Technology Engineering Center	5	0	5
Knolls	0	46	46
West Valley Demonstration Project	0	967	967
Total	337	1,013	1,350

origin and destination sites, total route miles, and the miles within each population zone for the 10 major generator-storage sites shipping CH-TRU waste are presented in Table E-5. This table also indicates the alternative under which the route would apply. Similar information is presented in Table E-6 for RH-TRU waste shipments. In Table E-7, the destination sites and mileages through each population zone for the small quantity sites are given.

The rural, suburban, and urban population route mileages along a given route were multiplied by state-specific rural, suburban, and urban accident, injury, or fatality rates to obtain route-specific impacts. The impacts were then summed over the route and divided by the total route mileage. For all but the State of New Mexico, the accident rate data for federally-aided interstate highways were used. For New Mexico, much of the waste travels on US-285, therefore, the rate data for federally-aided primary highways were used.

Route-specific per shipment accident, injury, and fatality rates (see Table E-8) were multiplied by the appropriate number of route shipments (Tables E-1 and E-2) to obtain the aggregate number of accidents, injuries, and fatalities. These impacts are shown in Table E-9. Because this analysis is not dependent on whether a truck is transporting full or empty TRU waste containers, twice the one-way mileage was used.

Table E-4
CH-TRU and RH-TRU Waste Shipments from Major Generator-Storage Sites to Treatment Sites

Waste Origin Site	Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Argonne National Laboratory - East	22	---	22	22	---	22	---	---	---
Idaho National Engineering Laboratory Argonne National Laboratory-West	---	---	---	---	---	---	---	---	---
Lawrence Livermore National Laboratory	137	---	137	137	---	137	---	---	---
Los Alamos National Laboratory	---	---	---	4,236	1,590	5,826	---	---	---
Mound Plant	50	3	53	50	3	53	---	---	---
Nevada Test Site	73	---	73	73	---	73	---	---	---
Rocky Flats Environmental Technology Site	---	---	---	2,102	---	2,102	---	---	---
Savannah River Site	---	---	---	---	---	---	---	---	---
Total	**282**	**3**	**285**	**6,620**	**1,593**	**8,213**	---	---	---
RH-TRU Waste									
Argonne National Laboratory - East	---	---	---	---	---	---	---	---	---
Idaho National Engineering Laboratory Argonne National Laboratory-West	1,098	454	1,552	1,098	454	1,552	1,098	454	1,552
Lawrence Livermore National Laboratory	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	128	66	194	128	66	194	128	66	194
Mound Plant	---	---	---	---	---	---	---	---	---
Nevada Test Site	---	---	---	---	---	---	---	---	---
Rocky Flats Environmental Technology Site	---	---	---	---	---	---	---	---	---
Savannah River Site	---	---	---	---	---	---	---	---	---
Total	**1,226**	**520**	**1,746**	**1,226**	**520**	**1,746**	**1,226**	**520**	**1,226**

Table E-4
CH-TRU and RH-TRU Waste Shipments From Major Generator-Storage Sites to Treatment Sites-Continued

Waste Origin Site	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Argonne National Laboratory - East	22	---	22	22	---	22	22	---	22
Idaho National Engineering Laboratory Argonne National Laboratory-West	---	---	---	---	---	---	---	---	---
Lawrence Livermore National Laboratory	137	---	137	137	---	137	137	---	137
Los Alamos National Laboratory	---	---	---	---	---	---	4,236	1,590	5,826
Mound Plant	50	3	53	50	3	53	50	3	53
Nevada Test Site	87	---	87	73	---	73	73	---	73
Oak Ridge National Laboratory	192	8	200	192	8	200	192	8	200
Rocky Flats Environmental Technology Site	---	---	---	---	---	---	2,102	---	2,102
Savannah River Site	---	---	---	---	---	---	---	---	---
Total	**488**	**11**	**499**	**474**	**11**	**485**	**6,812**	**1,601**	**8,413**
RH-TRU Waste									
Argonne National Laboratory - East	---	---	---	---	---	---	---	---	---
Idaho National Engineering Laboratory Argonne National Laboratory-West	1,098	454	1,552	1,098	454	1,552	1,098	454	1,552
Lawrence Livermore National Laboratory	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	128	66	194	128	66	194	128	66	194
Mound Plant	---	---	---	---	---	---	---	---	---
Nevada Test Site	---	---	---	---	---	---	---	---	---
Rocky Flats Environmental Technology Site	---	---	---	---	---	---	---	---	---
Savannah River Site	---	---	---	---	---	---	---	---	---
Total	**1,226**	**520**	**1,746**	**1,226**	**520**	**1,746**	**1,226**	**520**	**1,746**

Table E-5
CH-TRU Waste Transportation in Miles (Kilometers)

Originating Site	Destination Site	Total One-way Truck Mileage[a]	Population Zone			Applicable to the Following
			Rural	Suburban	Urban	
Argonne National Laboratory-East	WIPP	1,696 (2,729)	1,412 (2,272)	259 (417)	25 (40)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	SRS	877 (1,411)	587 (945)	266 (428)	24 (38)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Hanford Site (Hanford)	WIPP	1,807 (2,908)	1,645 (2,647)	144 (232)	18 (29)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3
Idaho National Engineering Laboratory/ANL-W	WIPP	1,392 (2,241)	1,263 (2,033)	114 (184)	15 (24)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3
Lawrence Livermore National Laboratory	WIPP	1,452 (2,337)	1,304 (2,099)	100 (161)	48 (77)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	Hanford	890 (1,432)	675 (1,086)	184 (296)	31 (50)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Los Alamos National Laboratory	WIPP	341 (549)	318 (512)	21 (34)	2 (3)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2C, and Action Alternative 3
	INEL	1,145 (1,843)	1,025 (1,650)	104 (167)	16 (26)	Action Alternative 2B, and No Action Alternative 1B
Mound Plant	WIPP	1,764 (2,838)	1,359 (2,187)	382 (614)	23 (37)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	SRS	639 (1,028)	424 (682)	205 (330)	10 (16)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Nevada Test Site	WIPP	1,194 (1,922)	1,118 (1,800)	63 (101)	13 (21)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	INEL	712 (1,146)	600 (966)	92 (148)	20 (32)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Oak Ridge National Laboratory	WIPP	1,439 (2,316)	1,160 (1,867)	265 (426)	14 (23)	Proposed Action, Action Alternative 1, and Action Alternative 2C
	SRS	357 (575)	245 (394)	109 (175)	3 (5)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Rocky Flats Environmental Technology Site	WIPP	704 (1,133)	619 (996)	71 (114)	14 (23)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2C, and Action Alternative 3
	INEL	732 (1,178)	669 (1,077)	54 (87)	9 (14)	Action Alternative 2B, and No Action Alternative 1B
Savannah River Site	WIPP	1,535 (2,470)	1,203 (1,936)	315 (507)	17 (27)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3

[a] Total mileages shown may differ from the sum of the population mileages due to rounding.

Table E-6
RH-TRU Waste Transportation in Miles (Kilometers)

Originating Site	Destination Site	Total One-way Truck Mileage[a]	Population Zone			Applicable to the Following
			Rural	Suburban	Urban	
Hanford (Richland) Site	WIPP	1,807 (2,908)	1,645 (2,647)	144 (232)	18 (29)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3
Idaho National Engineering Laboratory/ANL-W	WIPP	1,392 (2,240)	1,263 (2,033)	114 (183)	15 (24)	Proposed Action, and Action Alternative 1
	Hanford	600 (966)	550 (885)	47 (76)	3 (5)	Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Los Alamos National Laboratory	WIPP	342 (550)	318 (512)	22 (35)	2 (3)	Proposed Action, and Action Alternative 1
	Hanford	1,560 (2,511)	1,407 (2,264)	135 (217)	18 (29)	Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
Oak Ridge National Laboratory	WIPP	1,438 (2,314)	1,160 (1,867)	265 (426)	13 (21)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, and Action Alternative 3
Savannah River Site	ORNL	357 (575)	245 (394)	109 (175)	3 (5)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B, No Action Alternative 2

[a] Total mileages shown may differ from the sum of the population mileages due to rounding.

The distance traveled in an urban population zone and the impact factor for particulate and sulfur dioxide truck emissions (Rao et al. 1982) were used to estimate additional urban-area pollution health effects due to TRU waste shipments. The impact factor, 1.6×10^{-7} LCFs per mile (9.9×10^{-8} LCFs per kilometer), estimates the number of LCFs per urban mile traveled. The volume of particulates and sulfur dioxide emitted in an urban area by a single truck shipment would be quite small. A million or more simultaneous pollutant-generating shipments would be needed to achieve the minimum pollutant volume of particulates and sulfur dioxide required to cause one LCF. The LCFs attributed to diesel exhaust exposure in an urban area are very small relative to the impact of accidents, fatalities, or injuries.

E.3.1.1 Impact Results for Shipments from Major Sites to WIPP

Table E-9 summarizes the aggregate nonradiological impacts (accidents, injuries, fatalities, and pollution-related LCFs) associated with the transportation of TRU waste from the 10 major generator-storage sites by truck to WIPP. Impacts would be dependent on the number of shipments, which in turn, would be dependent on waste inventories and the differences in consolidation schemes and treatment options.

Table E-7
Mileages (Kilometers) to Treatment Sites from Sites with Small Quantities of TRU Waste

Originating Site	Destination Site	Total One-way Truck Mileage[a]	Population Zone			Applicable to the Following
			Rural	Suburban	Urban	
CH-TRU Waste						
Ames Laboratory	ORNL	893 (1,438)	669 (1,077)	209 (337)	15 (24)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	INEL	1,293 (2,081)	1,199 (1,930)	85 (137)	9 (15)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,255 (2,020)	1,121 (1,804)	118 (190)	16 (26)	Action Alternative 2C
Bettis Atomic Power Laboratory	ORNL	606 (975)	415 (668)	178 (286)	13 (21)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	SRS	686 (1,104)	485 (781)	188 (303)	12 (19)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,803 (2,902)	1,453 (2,338)	318 (512)	31 (50)	Action Alternative 2C
Pantex Plant	LANL	335 (539)	314 (505)	17 (27)	4 (6)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 2
	INEL	1,385 (2,229)	1,258 (2,025)	110 (177)	17 (27)	Action Alternative 2B and No Action Alternative 1B
	WIPP	443 (713)	413 (665)	27 (43)	4 (6)	Action Alternative 2C
Teledyne Brown Engineering	ORNL	787 (1,267)	462 (744)	292 (470)	33 (53)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	SRS	853 (1,373)	514 (827)	304 (489)	35 (56)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	2,198 (3,537)	1,661 (2673)	480 (772)	57 (92)	Action Alternative 2C
U.S. Army Materiel Command	ORNL	701 (1,128)	497 (800)	191 (307)	13 (21)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	INEL	1,429 (2,300)	1,323 (2,129)	98 (158)	8 (13)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,391 (2,239)	1,245 (2,004)	131 (211)	14 (23)	Action Alternative 2C
Paducah Gaseous Diffusion Plant	ORNL	316 (509)	252 (406)	60 (97)	4 (6)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	SRS	587 (945)	393 (632)	178 (286)	17 (27)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,360 (2,189)	1,174 (1,889)	171 (275)	14 (23)	Action Alternative 2C
Energy Technology Engineering Center	NTS	375 (603)	269 (433)	61 (98)	45 (72)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	INEL	958 (1,542)	755 (1,216)	142 (229)	62 (100)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,151 (1,853)	997 (1,605)	101 (163)	53 (85)	Action Alternative 2C
Sandia National Laboratories	LANL	104 (167)	82 (132)	17 (27)	5 (8)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 3, and No Action Alternative 2
	INEL	1,170 (1,884)	1,041 (1,676)	110 (177)	18 (29)	Action Alternative 2B and No Action Alternative 1B
	WIPP	311 (501)	288 (464)	19 (31)	4 (6)	Action Alternative 2C

[a] Total mileages shown may differ from the sum of the population mileages due to rounding.

Table E-7
Mileages (Kilometers) to Treatment Sites from Sites with Small Quantities of TRU Waste-Continued

Originating Site	Destination Site	Total One-way Truck Mileage*	Population Zone			Applicable to the Following
			Rural	Suburban	Urban	
CH-TRU Waste						
University of Missouri	ORNL	610 (982)	476 (766)	120 (193)	14 (23)	Proposed Action, Action Alternative 1, and No Action Alternative 2
	SRS	881 (1,418)	617 (993)	238 (383)	26 (42)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	1,145 (1,843)	1,018 (1,638)	110 (177)	18 (29)	Action Alternative 2C
ARCO Medical Products Company	ORNL	658 (1,059)	411 (662)	241 (388)	6 (10)	Action Alternative 1
	SRS	658 (1,059)	463 (745)	253 (407)	8 (13)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
	WIPP	2,056 (3,310)	1,608 (2,589)	420 (676)	27 (43)	Action Alternative 2C
Lawrence Berkeley Laboratory	Hanford	870 (1,400)	668 (1,075)	167 (269)	35 (56)	Action Alternative 1, Action Alternative 2B, Action Alternative 3, and No Action Alternative 1B
	WIPP	1,522 (2,450)	1,320 (2,125)	131 (211)	71 (114)	Action Alternative 2C
West Valley Demonstration Project	ORNL	749 (1,206)	467 (752)	265 (427)	17 (27)	Action Alternative 1
	SRS	902 (1,452)	635 (1,022)	259 (417)	9 (15)	Action Alternative 2A, Action Alternative 2B, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1B
RH-TRU Waste						
Battelle Columbus Laboratory	ORNL	395 (636)	269 (433)	117 (188)	9 (15)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, No Action Alternative 1A, Action Alternative 3, No Action Alternative 1,B, and No Action Alternative 2
Bettis Atomic Power Laboratory	ORNL	606 (976)	415 (668)	178 (287)	13 (21)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, No Action Alternative 1A, Action Alternative 3, No Action Alternative 1,B, and No Action Alternative 2
Knolls	ORNL	883 (1,422)	589 (948)	284 (457)	10 (16)	Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, No Action Alternative 1A, and No Action Alternative 1,B
Energy Technology Engineering Center	Hanford	1,203 (1,937)	982 (1,581)	179 (288)	41 (66)	Proposed Action, Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, No Action Alternative 1A, Action Alternative 3, No Action Alternative 1,B, and No Action Alternative 2
Sandia National Laboratories	LANL	104 (167)	82 (132)	17 (27)	5 (8)	Proposed Action, Action Alternative 1, No Action Alternative 1,B, and No Action Alternative 2
	Hanford	1,586 (2,553)	1,424 (2,293)	141 (227)	21 (34)	Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, Action Alternative 3, and No Action Alternative 1,B
West Valley Demonstration Project	ORNL	749 (1,206)	467 (752)	265 (427)	17 (27)	Action Alternative 1, Action Alternative 2A, Action Alternative 2B, Action Alternative 2C, No Action Alternative 1A, Action Alternative 3, and No Action Alternative 1,B

* Total mileages shown may differ from the sum of the population mileages due to rounding.

Table E-8
Nonradiological Impacts Per Shipment from Accidents and Pollution Related Health Effects

Originating Site	Destination Site	Impact Category	Population Zone			TOTAL[a]
			Rural	Suburban	Urban	
Argonne National Laboratory - East	WIPP	Accidents	1.3E-3	8.4E-04	6.3E-5	2.2E-3
		Injuries	1.2E-3	8.0E-04	6.0E-5	2.0E-3
		Fatalities	1.3E-4	1.0E-04	4.7E-6	2.4E-4
		Vehicle Pollution (LCFs)[b]	---	---	8.0E-6	8.0E-6
	SRS	Accidents	5.2E-4	8.6E-04	6.0E-5	1.4E-3
		Injuries	4.8E-4	8.3E-04	5.6E-5	1.4E-3
		Fatalities	5.3E-5	1.1E-04	4.5E-6	1.7E-4
		Vehicle Pollution (LCFs)[b]	---	---	7.6E-6	7.6E-6
Hanford Site	WIPP	Accidents	2.2E-3	3.7E-04	5.1E-5	2.6E-3
		Injuries	1.3E-3	2.9E-04	4.2E-5	1.6E-3
		Fatalities	1.7E-4	2.1E-05	2.8E-6	1.9E-4
		Vehicle Pollution (LCFs)[b]	---	---	5.8E-6	5.8E-6
Idaho National Engineering Laboratory/ANL-W	WIPP	Accidents	1.7E-3	3.4E-04	4.8E-5	2.1E-3
		Injuries	9.1E-4	2.6E-04	3.9E-5	1.2E-3
		Fatalities	1.4E-4	2.0E-05	2.7E-6	1.6E-4
		Vehicle Pollution (LCFs)[b]	---	---	4.9E-6	4.9E-6
	Hanford	Accidents	7.6E-4	1.4E-04	1.1E-5	9.1E-4
		Injuries	3.9E-4	1.1E-04	8.7E-6	5.1E-4
		Fatalities	6.0E-5	8.2E-06	5.9E-7	6.9E-5
		Vehicle Pollution (LCFs)[b]	---	---	1.1E-6	1.1E-6
Lawrence Livermore National Laboratory	WIPP	Accidents	1.2E-3	2.3E-04	8.3E-5	1.5E-3
		Injuries	9.3E-4	2.3E-04	1.2E-4	1.3E-3
		Fatalities	1.4E-4	1.7E-05	8.3E-6	1.7E-4
		Vehicle Pollution (LCFs)[b]	---	---	1.5E-5	1.5E-5
	Hanford	Accidents	6.0E-4	4.1E-4	5.4E-5	1.1E-03
		Injuries	4.8E-4	4.2E-4	7.9E-5	9.8E-04
		Fatalities	7.3E-5	3.2E-5	5.4E-6	1.1E-04
		Vehicle Pollution (LCFs)[b]	---	---	9.9E-6	9.9E-06
Los Alamos National Laboratory	WIPP	Accidents	3.2E-4	1.1E-4	1.1E-5	4.3E-4
		Injuries	3.1E-4	9.9E-5	9.7E-6	4.2E-4
		Fatalities	3.2E-5	1.0E-5	9.8E-7	4.3E-5
		Vehicle Pollution (LCFs)[b]			6.7E-7	6.7E-7
	Hanford	Accidents	1.4E-3	6.7E-4	9.2E-5	2.2E-03
		Injuries	1.4E-3	6.2E-4	8.5E-5	2.1E-03
		Fatalities	1.4E-4	6.3E-5	8.6E-6	2.1E-04
		Vehicle Pollution (LCFs)[b]	---	---	5.9E-6	5.9E-06
	INEL	Accidents	1.0E-3	5.2E-4	7.8E-5	1.6E-03
		Injuries	9.9E-4	4.8E-4	7.2E-5	1.5E-03
		Fatalities	1.0E-4	4.9E-5	7.3E-6	1.6E-04
		Vehicle Pollution (LCFs)[b]	---	---	5.0E-6	5.0E-06

[a] Totals may differ from the sum due to rounding.
[b] Dashed lines indicate that vehicle pollution impacts apply only to urban population zones.

Table E-8
Nonradiological Impacts Per Shipment from Accidents and Pollution Related Health Effects-Continued

Originating Site	Destination Site	Impact Category	Population Zone			TOTAL[a]
			Rural	Suburban	Urban	
Mound Plant	WIPP	Accidents	1.2E-3	1.0E-3	5.2E-5	2.3E-3
		Injuries	1.1E-3	1.0E-3	4.9E-5	2.2E-3
		Fatalities	1.2E-4	7.7E-5	3.6E-6	2.0E-4
		Vehicle Pollution (LCFs)[b]	---	---	7.4E-6	7.4E-6
	SRS	Accidents	3.8E-4	5.6E-4	2.3E-5	9.6E-4
		Injuries	3.5E-4	5.4E-4	2.2E-5	9.1E-4
		Fatalities	3.8E-5	4.1E-5	1.6E-6	8.1E-5
		Vehicle Pollution (LCFs)[b]	---	---	3.3E-6	3.3E-6
Nevada Test Site	WIPP	Accidents	1.0E-3	2.2E-4	5.1E-5	1.3E-3
		Injuries	1.0E-3	2.1E-4	4.7E-5	1.3E-3
		Fatalities	1.2E-4	2.3E-5	5.3E-6	1.5E-4
		Vehicle Pollution (LCFs)[b]	---	---	4.3E-6	4.3E-6
	INEL	Accidents	5.4E-4	3.2E-4	7.7E-5	9.4E-4
		Injuries	5.4E-4	3.0E-4	7.2E-5	9.1E-4
		Fatalities	6.4E-5	3.3E-5	8.0E-6	1.1E-4
		Vehicle Pollution (LCFs)[b]	---	---	6.5E-6	6.5E-6
Oak Ridge National Laboratory	WIPP	Accidents	9.9E-4	8.4E-4	4.7E-5	1.9E-3
		Injuries	9.7E-4	4.2E-4	4.4E-5	1.4E-3
		Fatalities	1.2E-4	7.2E-5	3.4E-6	1.9E-4
		Vehicle Pollution (LCFs)[b]	---	---	4.4E-6	4.4E-6
	SRS	Accidents	2.1E-4	3.4E-4	1.0E-5	5.6E-4
		Injuries	2.1E-4	1.7E-4	9.7E-6	3.9E-4
		Fatalities	2.5E-5	3.0E-5	7.5E-7	5.5E-5
		Vehicle Pollution (LCFs)[b]	---	---	9.6E-7	9.6E-7
Rocky Flats Environmental Technology Site	WIPP	Accidents	6.9E-4	2.7E-4	4.9E-5	1.0E-3
		Injuries	6.9E-4	2.4E-4	4.3E-5	9.7E-4
		Fatalities	6.7E-5	1.9E-5	2.9E-6	8.9E-5
		Vehicle Pollution (LCFs)[b]	---	---	4.5E-6	4.5E-6
	INEL	Accidents	7.5E-4	2.1E-4	3.1E-5	9.9E-4
		Injuries	7.4E-4	1.9E-4	2.7E-5	9.5E-4
		Fatalities	7.2E-5	1.5E-5	1.8E-6	8.9E-5
		Vehicle Pollution (LCFs)[b]	---	---	2.9E-6	2.9E-6
Savannah River Site	WIPP	Accidents	9.3E-4	6.0E-4	3.1E-5	1.6E-3
		Injuries	8.9E-4	5.8E-4	3.0E-5	1.5E-3
		Fatalities	1.2E-4	4.4E-5	2.3E-6	1.7E-4
		Vehicle Pollution (LCFs)[b]	---	---	5.5E-6	5.5E-6

[a] Totals may differ from the sum due to rounding.
[b] Dashed lines indicate that vehicle pollution impacts apply only to urban population zones

Table E-9
Aggregate Nonradiological Impacts for CH-TRU and RH-TRU Waste Transport[a]

Nonradiological Aggregate Impacts	Proposed Action Scaled to WIPP Max	Action Alternative 1			Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste													
Accidents	58	49	34	83	36	15	51	42	16	58	49	35	84
Injuries	37	32	21	53	23	9	32	26	9	35	32	21	53
Fatalities	5	4	3	7	3	1	4	3	1	4	4	3	7
Vehicle Pollution (LCF)	0.1	0.1	0.08	0.2	0.09	0.03	0.1	0.09	0.04	0.1	0.1	0.08	0.2
RH-TRU Waste													
Accidents	18	142	12	154	51	5	56	51	5	56	51	5	56
Injuries	11	87	8	95	31	3	34	31	3	34	31	3	34
Fatalities	1	11	1	12	4	1	5	4	1	5	4	1	5
Vehicle Pollution (LCF)	0.06	0.3	0.03	0.3	0.1	0.01	0.1	0.1	0.01	0.1	0.1	0.01	0.1
Total CH-TRU and RH-TRU Waste													
Accidents	76	191	46	237	87	20	107	93	21	114	100	40	140
Injuries	48	119	29	148	54	12	66	57	12	69	63	24	87
Fatalities	6	15	4	19	7	2	9	7	2	9	8	4	12
Vehicle Pollution (LCF)	0.2	0.4	0.1	0.5	0.2	0.04	0.2	0.2	0.05	0.3	0.2	0.09	0.3

[a] Total Inventory numbers may differ due to rounding.

Note: LCF = Latent Cancer Fatalities

Table E-9
Aggregate Nonradiological Impacts for CH-TRU and RH-TRU Waste Transport-Continued[a]

Nonradiological Aggregate Impacts	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Accidents	97	41	138	0.4	1.8E-5	0.4	9	3	12
Injuries	62	25	87	0.4	7.4E-3	0.4	9	3	12
Fatalities	7	3	10	0.04	5.8E-3	0.05	0.9	0.3	1
Vehicle Pollution (LCF)	0.2	0.09	0.3	2.3E-3	6.8E-4	2.4E-3	0.03	8.0E-3	0.04
RH-TRU Waste									
Accidents	177	16	193	1	0.5	2	1	0.5	2
Injuries	110	11	121	0.8	0.3	1	1	0.3	1
Fatalities	13	2	15	0.1	0.04	0.1	0.1	0.04	0.1
Vehicle Pollution (LCF)	0.4	0.04	0.4	1.9E-3	8.1E-4	2.7E-3	1.9E-03	8.1E-4	2.7E-03
Total CH-TRU and RH-TRU Waste									
Accidents	274	57	331	2	0.5	3	10	4	14
Injuries	172	36	208	1	0.3	1	10	3	13
Fatalities	20	5	25	0.1	0.04	0.1	1	0.3	1
Vehicle Pollution (LCF)	0.6	0.1	0.7	4.2E-03	8.2E-4	5.0E-03	0.03	3.6E-3	0.04

[a] Total Inventory numbers may differ due to rounding.

Note 1: LCF = Latent Cancer Fatalities
Note 2: Impacts for No Action Alternatives 1A and 1B reflect the number of shipments to consolidate TRU waste from generator-storage sites to treatment sites. No TRU waste would be shipped to WIPP.

E.4 RADIOLOGICAL IMPACTS FROM TRANSPORTATION ACCIDENTS

In this section, the impact analyses of the transportation of radioactive material are discussed. The impacts fall into two general categories, radiological impacts under normal transportation conditions and radiological impacts in the event of an accident.

These analyses were conducted in a manner consistent with WIPP-specific transportation analyses in SEIS-I (DOE 1990), the Engineered Alternatives Cost/Benefit Study Final Report (DOE 1995c), the Draft WM PEIS (DOE 1995b), and the Comparative Study of Waste Isolation Pilot Plant (WIPP) Transportation Alternatives (DOE 1994). The methods used were established by the NRC in the late 1970s.

The computer codes used for these analyses have been extensively documented elsewhere (Johnson et al. 1993a and 1993b, NRC 1977, and Neuhauser and Kanipe 1992). MICROSHIELD 4.21 was used to calculate the transportation index (TI) (radiation exposure rate at 1 meter [3.3 feet]) and RADTRAN was used to calculate radiological impacts (Neuhauser and Kanipe 1992). RADTRAN is the product of almost 15 years of development and is a flexible analytical tool for calculating the population impacts under both normal transportation and transportation accidents. The major RADTRAN input parameters are summarized in Table E-10. The RISKIND computer code (ANL 1995) was used to determine the maximally exposed individual (MEI) in an accident.

To evaluate the radiological impacts of accidents, it was necessary to consider the probability of an accident occurring and the potential consequences of that accident. This analysis included the following steps:

- Identifying the physical, chemical, and radiological characteristics of the waste
- Identifying the system that would be used for shipping (types of shipping containers, number of containers per shipment, etc.)
- Identifying potential accident scenarios in which radioactive material may be released
- Assigning a probability to each release scenario
- Estimating the amount and type of material likely to be released in each scenario (the release fraction)
- Evaluating the consequences of such a release, most often in terms of radiation dose to workers and the public

These analyses were performed to estimate the radiological impacts due to the shipment of TRU waste from the major generator-storage sites to WIPP.

E.4.1 Radiological Impacts Due to Accident-Free Transportation

Accident-free radiological impacts would occur during the routine transportation of radioactive material and are the result of public and worker exposures to external radiation (at levels allowed by transportation regulations). The dose rates would be low and would typically be less than that of natural background radiation.

Table E-10
RADTRAN Input for Transportation Analyses

Parameter	CH-TRU Waste	RH-TRU Waste
Configuration Data		
Mode of Transportation	Truck and Rail	Truck and Rail
Package type	TRUPACT-II	72B cask
Packages/Shipment	3	1
Package characteristic dimension, meter	7.4	3.6
Movement Data		
Shipment distance	Site/alternative specific (See Table E-5 and E-6)	
Population density	Route/alternative specific per Highway or Interline Routing Models	
Shipment Speed (kilometer/hour)		
Urban	24.2	24.2
Suburban	40.3	40.3
Rural	88.6	88.6
Stop time (hour) per kilometer	0.01	0.01
Other Normal Input	RADTRAN 4 default values	RADTRAN 4 default values
Normal Exposure Data		
Transportation Index, TI (mrem/hour)	Site/alternative specific	Site/alternative specific
Number of crew members	2	3
Effective distance from source to crew	10	19
Number of people per public vehicle	2	2
Number of people exposed per stop	50	719 persons per square kilometer
Exposure distance while stopped, meters	20	10 to 400 meters
Accident Exposure Data		
Number of accident severity categories	8	8
Accident severity category frequency	(NUREG-0170 values)	(NUREG-0170 values)
Radioactive contents/parameters	See Table E-17	See Table E-17
Release fractions	See Table E-20	See Table E-21
Other accident inputs	RADTRAN 4 default values	RADTRAN 4 default values

Note: Accident, injury, and fatality rates were determined for each route using state-specific data (Saricks and Kvitek 1994)

E.4.1.1 Calculating Radiological Impacts from Accident-Free Transportation

To determine the radiological impacts of accident-free transportation, the TRU waste volumes, the number of shipments that would be required to transport the waste, the number of miles traveled, and a breakdown of the miles traveled according to urban, suburban, and rural population zones were used. The accident-free radiological impacts, expressed in person-rem, were converted to LCFs using a conversion factor of 1 person-rem = 5×10^{-4} LCFs for nonoccupational doses and 1 person-rem = 4×10^{-4} LCFs for occupational doses (ICRP 1991).

Among the more important RADTRAN input parameters are: the TI, the frequency of stops, the number of people exposed and their distances from the package surface, and the speed of the vehicle used for transportation. The following categories of accident-free occupational and nonoccupational exposures were assessed using RADTRAN (the nomenclature provided in the output are identified in parentheses):

- ***Along Route*** *(Off Link Exposure):* Exposure to individuals adjacent to routes of travel
- ***Sharing Route*** *(On Link Exposure):* Exposure to individuals sharing the right-of-way
- ***Stops*** *(Stops):* Exposure to individuals while shipments are at rest stops
- ***Occupational*** *(Occupational Exposure):* Exposure to vehicle crews

Radiation doses from the first three were summed to obtain the total nonoccupational radiation dose. Additional analyses, discussed later in this section, were conducted to identify the potential impact to the individual likely to receive the greatest radiation dose, such as the state shipment inspector or an individual living along the route.

The TI represents the radiation dose rate at 1 meter (3.3 feet) from the surface of the shipping package and is dependent on the waste density, distribution of radionuclides, quantity of radionuclides per shipment, mix of waste types, self-shielding provided by the waste, and shielding provided by the package. The TI is, therefore, very sensitive to small quantities of gamma-emitting radionuclides such as cobalt-60 (Co-60) and cesium-137 (Cs-137).

Typically, the radionuclide composition of the waste is different for each generator site, and the radionuclide composition of the waste is different from one waste stream to another. BIR-2 considers 11 different waste groups, ranging from paper to vitrified waste. For shipments to WIPP, an average radionuclide composition was developed for each site using the BIR-2 database information and information provided in the Integrated Data Base (IDB) (see Appendix A for additional details).

The shielding dimensions of the TRUPACT-II and RH-72B were used in MICROSHIELD (Worku and Negin 1995) to estimate the external dose rates from unit concentrations of the gamma-emitting radionuclides expected to make the greatest exposure impact. The dose rates were then multiplied by the activity of each radionuclide in the TRU waste inventory for each site to determine an external-dose screening value. These values indicate the comparative impact from external radiation for each radionuclide in the TRU waste inventory at each site. The radionuclides of greatest concern throughout the DOE complex would be americium-241 (Am-241), Cs-137, barium-137m (Ba-137m), and Co-60.

Dose rates were tabulated in a spreadsheet for each radionuclide in the TRU waste inventory to determine the TI. In most cases, the calculated TI was much less than 1; however, because the radionuclide inventory information may be highly variable, a TI of 4 was assumed for all CH-TRU shipments, and a TI of 10 was assumed for all RH-TRU shipments. No calculated TI exceeded these assumed values. Table E-11 presents the TIs calculated for each site for the Proposed Action and each action alternative.

Table E-11
Transportation Indices for TRU Waste Transported from the 10 Major Sites (millirem per hour at 1 meter [3.3 feet])[a]

Sites	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3
CH-TRU Waste						
ANL-E	4.9E-3	4.1E-3	---	---	4.1E-3	---
HANFORD	2.2	3.3	2.8	2.8	3.3	2.7
INEL	0.6	0.7	1.5	1.3	0.7	0.6
LANL	0.3	0.3	0.8	---	1.3	0.2
LLNL	1.1E-3	9.7E-4	---	---	9.7E-4	---
MOUND	3.2E-5	2.7E-5	---	---	3.0E-5	---
NTS	0.05	0.04	---	---	0.04	---
ORNL	0.2	0.2	---	---	0.2	---
RFETS	0.02	0.02	0.09	---	0.05	0.02
SRS	0.07	0.06	0.2	0.2	0.06	0.06
RH-TRU Waste						
HANFORD	1.2	1.2	3.2	3.2	3.2	9.2
INEL	0.6	0.6	---	---	---	---
LANL	0.1	0.1	---	---	---	---
ORNL	0.6	0.4	1.1	1.1	1.1	1.0

[a] Dashes indicate that no TRU waste would be shipped to WIPP.

Note: The actual TI used for CH-TRU waste was 4, and the actual TI used for RH-TRU waste was 10.

RADTRAN classified those living along the shipment routes as urban, suburban, and rural fractions with respective mean population densities of 3,861, 719, and 6 persons per square kilometer (10,003, 1,863, and 16 per square mile). This classification is based upon the *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977) and the population densities are quite typical of urban, suburban, and rural environments. For example, statistics from the Denver Regional Council of Governments show that, along I-25 through Denver, only a small area around downtown Denver has a population density that exceeds the urban figure used in RADTRAN (3,997 persons per square kilometer (10,354 per square mile) for Denver versus the 3,861 persons per square kilometer assumed by RADTRAN). Other segments through Denver have much lower population densities than the RADTRAN urban value. Fifteen miles south of downtown Denver, population densities along I-25 approach the rural value of 6 persons per square kilometer.

Exposure scenarios were determined to assess the potential impacts from occupational and nonoccupational radiation doses. Some individuals would be exposed to only a single shipment while others would be exposed to multiple shipments. Transportation crew members would be monitored with radiation dosimeters to limit exposures. Radiation dose assessments included the following scenarios:

- A person in a traffic jam next to a truck transporting TRU waste. For this assessment, the exposure distance was assumed to be 1 meter (3.3 feet) and the exposure time assumed to be 30 minutes. The person was assumed to be exposed only once.

- An inspector of trucks ready for departure from a site. For this assessment, it was assumed that the inspector would have an exposure distance of 1 meter (3.3 feet) for 30 minutes, the inspector would work at the same job for 10 years, and there would be two shifts working the same job. The number of shipments inspected by and individual would depend on the total number of shipments from a site and the rate at which they were shipped.

- A state safety inspector. For this assessment, it was assumed that the inspector would be involved in 20 percent of the inspections over a 10-year period with an average exposure distance of approximately 1 meter (3.3 feet). Inspections may occur at the origin facility, upon arrival at WIPP, or in the corridor states at ports of entry for trucks. To allow for queues, a truck inspection time of 1 hour was used. To bound the state inspector dose, the route on which the majority of the waste (77 percent) enters New Mexico was chosen.

- A person residing along a shipment route. For this assessment, it was assumed that the individual would be exposed to every waste shipment for 70 years, at a distance of approximately 30 meters (98.4 feet).

- A rest stop employee. For this assessment, a stop duration of 2 hours and an exposure distance of 20 meters (66 feet) were assumed. It was also assumed that the individual would be exposed to approximately 20 percent of all CH-TRU and RH-TRU waste shipments sent to WIPP over a 10-year period. This assumption was made on the basis that all trucks stopped at the same location, an individual worked for 10 years at the truck stop, and 3 shifts worked at the truck stop.

- A driver of a truck hauling TRU waste. For this assessment, doses were assessed both when the truck was moving and when it was stopped. An exposure distance of 4 meters (13.1 feet) was assumed. Doses received while the trucks were stopped were assumed to be due to inspections every 100 miles, refueling, and food stops. A truck driver, rather than a service attendant, was assumed to refuel the truck. Depending upon the number of shipments from a facility and the travel time to WIPP, a truck driver may transport all or only a fraction of the shipments from a particular site. It should be noted that no matter what the estimated impacts are, current regulations state that any monitored crew member who receives a radiation dose that approaches 2 rem (the administrative limit for occupational doses) in any given year is to be reassigned to other duties involving no further dose for the remainder of the year.

Table 3-17 in Chapter 3 presents the amount of time required to emplace CH-TRU and RH-TRU waste under the Proposed Action and the action alternatives based upon a throughput rate of 50 TRUPACT-IIs and 8 RH-72Bs per week. This information was used to estimate the maximum number of shipments that the MEI would be exposed to. All doses were determined during a time of maximum shipping. As indicated in Table 3-17, there would be a period of time under the action alternatives when all CH-TRU waste would have been emplaced and only RH-TRU waste would remain. At that time, accident-free radiological impacts would be considerably less because fewer shipments would be traveling along the routes.

E.4.1.2 Impact Results for Accident-Free Transportation Analyses

Accident-free radiological impacts (per shipment) for CH-TRU and RH-TRU waste shipments from the 10 major generator sites to WIPP are presented in Tables E-12 and E-13. Results are presented as the population dose (person-rem) for occupational and nonoccupational groups for each site. These population doses were used to calculate the aggregate accident-free doses from CH-TRU and RH-TRU waste transportation. Table E-14 summarizes these doses according to alternative and provides the mathematically expected LCFs.

MEI doses are presented in Table E-15, as are the corresponding LCFs from CH-TRU and RH-TRU waste transportation.

E.4.2 Radiological Impacts of Transportation Accidents

Radiological impacts due to transportation accidents could be incurred if any radioactive material were released into the environment. The greatest potential impact from such releases would occur when alpha-emitting radionuclides are either inhaled or ingested.

As previously discussed, NRC-certified Type B packages (TRUPACT-II and RH-72B cask) used to ship CH-TRU and RH-TRU waste must undergo a series of performance tests which simulate accident conditions. These tests include drops, punctures, exposure to fire, and water immersion. The packages are passed if no radioactive material is released as a result of the tests.

A 1987 NRC study (Fischer et al. 1987) estimated that only 0.6 percent of truck and rail accidents involving Type B containers or casks could cause a radiation hazard to the public. The highest number of potential accidents (nonradiological), as calculated in Section E.3, would be expected under Action Alternative 3 and would be about 331. Only half of these accidents would be expected to occur when the canister or cask is loaded; the other half would occur when the trucks were transporting empty canisters or casks back to sites. Therefore, of the 166 potential accidents occurring from transportation of TRU waste under Action Alternative 3, only one accident would be expected to result in damage to the package.

An earlier NRC study (NRC 1977) conservatively estimated that 91 percent of truck and 80 percent of rail accidents are category I and II accidents (packaging must survive without a release). Therefore, 9 percent of truck and 20 percent of rail accidents involving Type B containers or casks could result in radioactive material releases and could be more severe than the test conditions. Therefore, approximately 15 truck-related accidents could occur in which the loaded Type B container is subjected to conditions beyond those associated with severity categories I or II. Some of the low-probability events could result in a release from a Type B package. In order to assure conservative (bounding) impact estimates, the more conservative statistics from the older 1977 NRC study were used in these analyses.

Two analyses were conducted for radiological impacts due to transportation accidents. The first analysis assessed the radiological impact due to transportation accidents occurring from each of the 10 major treatment sites to WIPP. For this analysis, a conservative radiological inventory, which assumed that every TRU waste package would be filled with waste containing the highest level of radionuclides and hazardous material allowed by the planning-basis WAC. The total accident impact for each of the 10 sites was obtained by summing the calculated risks of each severity class.

Table E-12
Population Dose by Exposure Category per CH-TRU Waste Shipment

Origination Site	Destination Site	Exposure Category	Population Dose (person-rem)	Applicable to the Following
Argonne National Laboratory - East	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, and Action Alternative 2C
		Nonoccupational		
		Stops	0.2	
		Sharing Route	9.7E-3	
		Along Route	5.3E-3	
		Total[a]	0.2	
	SRS	Occupational	0.02	Action Alternatives 2A and 2B Action Alternative 3, No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.08	
		Sharing Route	5.7E-3	
		Along Route	5.2E-3	
		Total[a]	0.1	
Hanford Site	WIPP	Occupational	0.3	Proposed Action, Action Alternative 1; Action Alternatives 2A, 2B, and 2C; and Action Alternative 3
		Nonoccupational		
		Stops	0.2	
		Sharing Route	9.7E-3	
		Along Route	3.3E-3	
		Total[a]	0.2	
Idaho National Engineering Laboratory/ANL-W	WIPP	Occupational	0.02	Proposed Action, Action Alternative 1; Action Alternatives 2A, 2B, and 2C; and Action Alternative 3
		Nonoccupational		
		Stops	0.1	
		Sharing Route	7.5E-3	
		Along Route	2.7E-3	
		Total[a]	0.1	
Lawrence Livermore National Laboratory	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, and Action Alternative 2C
		Nonoccupational		
		Stops	0.1	
		Sharing Route	8.5E-3	
		Along Route	4.8E-3	
		Total[a]	0.2	
	Hanford	Occupational	0.02	Action Alternatives 2A and 2B; Action Alternative 3; and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.09	
		Sharing Route	5.7E-3	
		Along Route	4.6E-3	
		Total[a]	0.1	
Los Alamos National Laboratory	WIPP	Occupational	6.0E-3	Proposed Action; Action Alternative 1; Action Alternatives 2A and 2C; and Action Alternative 3
		Nonoccupational		
		Stops	0.03	
		Sharing Route	1.8E-3	
		Along Route	4.6E-4	
		Total[a]	0.04	
	INEL	Occupational	0.02	Action Alternative 2B and No Action Alternative 1A
		Nonoccupational		
		Stops	0.1	
		Sharing Route	5.6E-3	
		Along Route	1.4E-4	
		Total[a]	0.1	

[a] Nonoccupational doses include exposure to people at stops, sharing the route, and along the route.

Table E-12
Population Dose by Exposure Category per CH-TRU Waste Shipment-Continued

Origination Site	Destination Site	Exposure Category	Population Dose (person-rem)	Applicable to the Following
Mound Plant	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, and Action Alternative 2C
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	6.7E-3	
		Total[a]	0.2	
	SRS	Occupational	0.01	Action Alternatives 2A and 2B; Action Alternative 3; and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.06	
		Sharing Route	4.0E-3	
		Along Route	3.4E-3	
		Total[a]	0.07	
Nevada Test Site	WIPP	Occupational	0.02	Proposed Action, Action Alternative 1, and Action Alternative 2C
		Nonoccupational		
		Stops	0.1	
		Sharing Route	6.4E-3	
		Along Route	1.9E-3	
		Total[a]	0.1	
	INEL	Occupational	0.01	Action Alternatives 2A and 2B; Action Alternative 3; and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.07	
		Sharing Route	4.3E-3	
		Along Route	2.7E-3	
		Total[a]	0.08	
Oak Ridge National Laboratory	WIPP	Occupational	0.03	Proposed Action, Action Alternative 1, Action Alternative 2C
		Nonoccupational		
		Stops	0.1	
		Sharing Route	8.2E-3	
		Along Route	4.5E-3	
		Total[a]	0.2	
Oak Ridge National Laboratory	SRS	Occupational	6.2E-3	Action Alternatives 2A and 2B; Action Alternative 3; and No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.03	
		Sharing Route	2.2E-3	
		Along Route	1.6E-3	
		Total[a]	0.04	
Rocky Flats Environmental Technology Site	WIPP	Occupational	0.01	Proposed Action; Action Alternative 1; Action Alternatives 2A and 2C; and Action Alternative 3
		Nonoccupational		
		Stops	0.07	
		Sharing Route	4.0E-3	
		Along Route	2.0E-3	
		Total[a]	0.07	
	INEL	Occupational	0.01	Action Alternative 2B and No Action Alternative 1B
		Nonoccupational		
		Stops	0.07	
		Sharing Route	3.6E-3	
		Along Route	7.9E-5	
		Total[a]	0.08	
Savannah River Site	WIPP	Occupational	0.03	Proposed Action; Action Alternative 1; Action Alternatives 2A, 2B, and 2C; and Action Alternative 3
		Nonoccupational		
		Stops	0.1	
		Sharing Route	8.9E-3	
		Along Route	5.4E-3	
		Total[a]	0.2	

[a] Nonoccupational doses include exposure to people at stops, sharing the route, and along the route.

Table E-13
Population Dose by Exposure Category per RH-TRU Waste Shipment

Origination Site	Destination Site	Exposure Category	Population Dose (person-rem)	Applicable to the Following
Hanford (Richland) Site	WIPP	Occupational	0.01	Proposed Action; Action Alternative 1; Action Alternatives 2A, 2B, and 2C; and Action Alternative 3
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	4.4E-3	
		Total[a]	0.2	
Idaho National Engineering Laboratory/ANL-W	WIPP	Occupational	9.0E-3	Proposed Action, and Action Alternative 1
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	3.6E-3	
		Total[a]	0.2	
	Hanford	Occupational	3.9E-3	Action Alternatives 2A, 2B, and 2C; Action Alternative 3 No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.08	
		Sharing Route	4.2E-3	
		Along Route	1.2E-3	
		Total[a]	0.08	
Los Alamos National Laboratory	WIPP	Occupational	2.2E-3	Proposed Action, and Action Alternative 1
		Nonoccupational		
		Stops	0.04	
		Sharing Route	2.4E-3	
		Along Route	6.1E-4	
		Total[a]	0.05	
	Hanford	Occupational	0.01	Action Alternatives 2A, 2B, and 2C; Action Alternative 3; No Action Alternatives 1A and 1B
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	4.2E-3	
		Total[a]	0.2	
Oak Ridge National Laboratory	WIPP	Occupational	9.3E-3	Proposed Action; Action Alternative 1; Action Alternatives 2A, 2B, and 2C; and Action Alternative 3
		Nonoccupational		
		Stops	0.2	
		Sharing Route	0.01	
		Along Route	6.0E-3	
		Total[a]	0.2	

[a] Nonoccupational doses include exposure to people at stops, sharing the route, and along the route.

Table E-14
Aggregate Accident-Free Dose (person-rem) from CH-TRU and RH-TRU Waste Shipments [a, b]

Exposure Category	Proposed Action Scaled to WIPP Max	Action Alternative 1			Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste													
Occupational	710 (0.3)	600 (0.2)	410 (0.2)	1.0E+3 (0.4)	450 (0.2)	180 (0.07)	630 (0.3)	515 (0.2)	190 (0.08)	705 (0.3)	600 (0.3)	413 (0.2)	1,013 (0.5)
Nonoccupational													
Stops	3.9E+3 (2)	3.3E+3 (1.7)	2.2E+3 (1.1)	5.5E+3 (2.8)	2.5E+3 (1.3)	970 (0.5)	3.5E+3 (1.8)	2.8E+3 (1.6)	1.0E+3 (0.5)	3.9E+3 (2.1)	3.3E+3 (1.7)	2.3E+3 (1.1)	5.6E+3 (2.8)
Sharing Route	220 (0.1)	190 (0.1)	130 (0.07)	320 (0.2)	140 (0.07)	55 (0.03)	195 (0.1)	160 (0.09)	60 (0.03)	220 (0.1)	185 (0.09)	127 (0.06)	312 (0.2)
Along Route	85 (0.04)	70 (0.04)	45 (0.02)	115 (0.06)	55 (0.03)	20 (9.7E-3)	75 (0.04)	60 (0.04)	20 (0.01)	80 (0.05)	70 (0.04)	45 (0.02)	115 (0.06)
Nonoccupational Total[c]	4.2E+3 (2.1)	3.5E+3 (1.8)	2.4E+3 (1.2)	5.9E+3 (3.0)	2.7E+3 (1.4)	1.0E+3 (0.5)	3.7E+3 (1.9)	3.0E+3 (1.8)	1.1E+3 (0.6)	4.1E+3 (2.3)	3.6E+3 (1.8)	2.4E+3 (1.2)	5.9E+3 (3.0)
RH-TRU Waste													
Occupational	80 (0.03)	630 (0.3)	55 (0.02)	685 (0.3)	225 (0.09)	20 (8.8E-3)	245 (0.1)	225 (0.09)	20 (8.8E-3)	245 (0.1)	225 (0.09)	20 (8.8E-3)	245 (0.1)
Nonoccupational													
Stops	1.6E+3 (0.8)	1.3E+4 (6.5)	1.1E+3 (0.6)	1.4E+4 (7.1)	4.5E+3 (2.3)	435 (0.2)	4.9E+3 (2.5)	4.5E+3 (2.3)	435 (0.2)	4.9E+3 (2.5)	4.5E+3 (2.3)	435 (0.2)	4.9E+3 (2.5)
Sharing Route	90 (0.05)	700 (0.4)	60 (0.03)	760 (0.4)	250 (0.1)	25 (0.01)	275 (0.1)	250 (0.1)	25 (0.01)	275 (0.1)	250 (0.1)	25 (0.01)	275 (0.1)
Along Route	35 (0.02)	255 (0.1)	30 (0.01)	285 (0.1)	90 (0.05)	10 (5.5E-3)	100 (0.05)	90 (0.05)	10 (5.5E-3)	100 (0.05)	90 (0.05)	10 (5.5E-3)	100 (0.05)
Nonoccupational Total[c]	1.7E+3 (0.9)	1.4E+4 (7.0)	1.2E+3 (0.6)	1.5E+4 (7.6)	4.8E+3 (2.4)	470 (0.2)	5.3E+3 (2.7)	4.8E+3 (2.5)	470 (0.2)	5.3E+3 (2.7)	4.8E+3 (2.5)	470 (0.2)	5.3E+3 (2.7)
Total CH-TRU and RH-TRU Waste													
Occupational	790 (0.3)	1.2E+3 (0.5)	465 (0.2)	1.7E+3 (0.7)	675 (0.3)	200 (0.08)	875 (0.4)	815 (0.3)	220 (0.09)	1.0E+3 (0.4)	825 (0.4)	435 (0.2)	1.3E+3 (0.6)
Nonoccupational													
Stops	5.5E+3 (2.8)	1.6E+4 (8.2)	3.3E+3 (1.7)	1.9E+4 (9.9)	7.0E+3 (3.6)	1.4E+3 (0.7)	8.4E+3 (4.3)	7.8E+3 (3.9)	1.5E+3 (0.8)	9.3E+3 (4.7)	7.8E+3 (4.0)	2.7E+3 (1.3)	1.1E+4 (5.3)
Sharing Route	310 (0.2)	890 (0.4)	190 (0.09)	1.1E+3 (0.5)	390 (0.2)	80 (0.04)	470 (0.2)	430 (0.2)	85 (0.04)	515 (0.3)	435 (0.2)	155 (0.07)	590 (0.3)
Along Route	120 (0.06)	325 (0.2)	75 (0.04)	400 (0.2)	145 (0.1)	30 (0.02)	175 (0.1)	160 (0.08)	30 (0.02)	190 (0.1)	160 (0.08)	55 (0.03)	215 (0.1)
Nonoccupational Total[c]	5.9E+3 (3.0)	1.7E+4 (8.8)	3.6E+3 (1.8)	2.1E+4 (10.6)	7.5E+3 (3.9)	1.5E+3 (0.7)	9.0E+3 (4.6)	8.3E+3 (4.2)	1.6E+3 (0.8)	1.0E+4 (5.0)	8.4E+3 (4.3)	3.0E+3 (1.4)	1.2E+4 (5.7)

[a] Number in parentheses equals LCFs.
[b] Total Inventory numbers may differ due to rounding.
[c] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route.

Table E-14
Aggregate Accident-Free Dose (person-rem) from CH-TRU and RH-TRU Waste Shipments—Continued [a, b]

Exposure Category	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Occupational	1.2E+3 (0.5)	500 (0.2)	1.7E+3 (0.7)	5 (2.0E-3)	0.08 (3.2E-5)	5 (2.0E-3)	117 (0.05)	32 (0.01)	149 (0.06)
Nonoccupational									
Stops	6.5E+3 (3.3)	2.7E+3 (1.4)	9.2E+3 (4.7)	28 (0.01)	0.5 (2.5E-4)	29 (0.01)	640 (0.3)	175 (0.09)	815 (0.4)
Sharing Route	370 (0.2)	150 (0.08)	520 (0.3)	2 (9.0E-4)	0.03 (1.5E-5)	2 (9.0E-4)	38 (0.02)	10 (5.0E-3)	48 (0.03)
Along Route	130 (0.07)	55 (0.03)	185 (0.1)	1 (5.0E-4)	0.02 (1.0E-5)	1 (5.0E-4)	15 (7.5E-3)	4 (2.0E-3)	19 (0.01)
Nonoccupational Total[c]	7.0E+3 (3.6)	2.9E+3 (1.5)	9.9E+3 (5.1)	31 (0.02)	0.6 (3.0E-4)	32 (0.02)	700 (0.4)	190 (0.1)	890 (0.5)
RH-TRU Waste									
Occupational	760 (0.3)	50 (0.02)	810 (0.3)	6 (2.2E-3)	2 (8.8E-4)	8 (3.1E-3)	6 (2.2E-3)	2 (8.8E-4)	8 (3.1E-3)
Nonoccupational									
Stops	1.5E+4 (7.5)	1.0E+3 (0.5)	1.6E+4 (8.0)	110 (0.06)	43 (0.02)	153 (0.08)	110 (0.06)	43 (0.02)	153 (0.08)
Sharing Route	840 (0.4)	60 (0.03)	900 (0.4)	6 (2.2E-3)	2 (8.8E-4)	8 (3.1E-3)	6 (2.2E-3)	2 (8.8E-4)	8 (3.1E-3)
Along Route	300 (0.1)	25 (0.01)	325 (0.1)	2 (8.8E-4)	0.8 (4.0E-4)	3 (1.4E-4)	2 (8.8E-4)	0.8 (4.0E-4)	3 (1.4E-4)
Nonoccupational Total[c]	1.6E+4 (8.0)	1.1E+3 (0.6)	1.7E+4 (8.6)	118 (0.06)	46 (0.02)	164 (0.08)	118 (0.06)	46 (0.02)	164 (0.08)
Total CH-TRU and RH-TRU Waste									
Occupational	2.0E+3 (0.8)	550 (0.2)	2.5E+3 (1.0)	11 (4.4E-3)	2 (8.8E-4)	13 (5.2E-3)	123 (0.05)	34 (0.02)	157 (0.07)
Nonoccupational									
Stops	2.2E+4 (10.8)	3.7E+3 (1.9)	2.5E+4 (12.7)	138 (0.07)	44 (0.02)	182 (0.09)	750 (0.4)	218 (0.1)	968 (0.5)
Sharing Route	1.2E+3 (0.6)	210 (0.1)	1.4E+3 (0.7)	8 (4.0E-3)	2 (1.2E-3)	10 (5.2E-3)	44 (0.02)	12 (6.0E-3)	56 (0.03)
Along Route	430 (0.2)	80 (0.04)	510 (0.2)	3 (1.5E-3)	0.8 (3.8E-4)	4 (1.9E-3)	17 (8.5E-3)	5 (2.5E-3)	22 (0.01)
Nonoccupational Total[c]	2.3E+4 (11.6)	4.0E+3 (2.1)	2.7E+4 (13.7)	149 (0.07)	47 (0.03)	196 (0.1)	818 (0.4)	236 (0.1)	1.1E+3 (0.5)

[a] Number in parentheses equals LCFs.
[b] Total Inventory numbers may differ due to rounding.
[c] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route.

Table E-15
Dose (rem) and LCF (values in parentheses) to MEIs from CH-TRU and RH-TRU Waste Shipments

MEI	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3
CH-TRU Waste						
Person in traffic jam next to shipment	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)	5.0E-3 (2.5E-6)
Departure Inspectors	2.7 (1.1E-3)	1.7 (6.8E-4)	1.6 (6.4E-4)	1.6 (6.4E-4)	1.7 (6.8E-4)	1.8 (7.2E-4)
State Inspector	2.4 (9.6E-4)	2.5 (1.0E-3)	2.6 (1.0E-3)	3.2 (1.3E-3)	2.5 (1.0E-3)	2.6 (1.0E-3)
Individual residing adjacent to access route	0.5 (2.5E-4)	0.6 (3.0E-4)	0.4 (2.0E-4)	0.5 (2.5E-4)	0.6 (3.0E-4)	1.0 (5.0E-4)
Rest stop employee	2.9 (1.5E-3)	0.3 (1.5E-4)	0.3 (1.5E-4)	0.4 (2.0E-4)	0.3 (1.5E-4)	0.3 (1.5E-4)
RH-TRU Waste						
Person in traffic jam next to shipment	0.01 (5.0E-6)	0.01 (5.0E-6)	0.01 (5.0E-6)	0.01 (5.0E-6)	0.01 (5.0E-6)	0.01 (5.0E-6)
Departure Inspector	2.8 (1.1E-3)	18.5 (7.4E-3)	16.0 (6.4E-3)	16.0 (6.4E-3)	16.0 (6.4E-3)	15.8 (6.3E-3)
State Inspectors	1.3 (5.2E-4)	4.8 (1.9E-3)	3.9 (1.6E-3)	3.9 (1.6E-3)	3.9 (1.6E-3)	4.1 (1.6E-3)
Individual residing adjacent to access route	0.3 (1.5E-4)	1.5 (7.5E-4)	0.9 (4.5E-4)	0.9 (4.5E-4)	0.9 (4.5E-4)	1.1 (5.5E-4)
Rest stop employee	3.5 (1.8E-3)	0.5 (2.5E-4)	0.4 (2.0E-4)	0.4 (2.0E-4)	0.4 (2.0E-4)	0.4 (2.0E-4)

The second analysis assessed four bounding accidents. Two accidents were assumed to involve the breach of a TRUPACT-II, and two accidents involved the breach of an RH-72B. The accidents were assumed to occur under conditions which maximized, within reasonable bounds, the impacts to exposed populations. The probability that such an accident would occur is less than 7.5×10^{-7} for a truck shipment of severity category VIII.

E.4.2.1 Calculating Radiological Impacts of Transportation Accidents

This section discusses the processes used to calculate the radiological impact due to transportation accidents. Among the elements which are important to such calculations are the severity calculations, release fractions, and the dispersal of released material.

Severity Categories

Most transportation accidents are unlikely to cause any radioactive material release, but very severe accidents may. Thus, the distribution of accidents according to severity must be determined in addition to the overall accident rate.

Accident severity categories define the seriousness of an accident in terms of mechanical and thermal loads. Relevant mechanical parameters include impact speed, force, location and orientation, surface hardness, and puncture characteristics. Thermal characteristics include flame

temperature, fire duration, fire source size and orientation with respect to the container, and heat transfer properties (such as flame emissivity and convection coefficients).

NRC defined eight accident severity categories for each mode of transportation in a study assessing the adequacy of regulations for radioactive material transportation (NRC 1977). Severity category I and II accidents are equivalent to the regulatory accident tests required for Type A and Type B packages. By definition, category I and II accidents do not result in any environmental releases because the shipping containers or casks are designed to withstand the accidents. RADTRAN severity categories III through VIII represent accidents that are more severe than the regulatory accident tests.

Releases from crush impacts were not expected below accident severity category V. Releases from the TRUPACT-II were assumed to be possible during accidents involving fires in category III or above. The large majority of truck (99.90 percent) and rail (99.83 percent) accidents that involve fires last less than 30 minutes (Wolff 1984). The release fractions were combined with the accident rates (probability of fire or impact) for each severity category, the travel distance per shipment, and the fraction of travel through each population density zone to determine an aggregate, probability-weighted consequence for each shipment in terms of radiation dose and LCFs. The probability that an accident will occur diminishes as the accident severity increases. SEIS-II retains the severity classification scheme used by the NRC (1977). The fractional occurrence of truck accidents in each of the eight severity categories is presented in Table E-16.

Table E-16
Fractional Truck Accident Occurrences by Accident Severity Category and Population Density Zone

Accident Severity Category	Fractional Occurrences	Rural	Suburban	Urban
I	0.55	0.1	0.1	0.8
II	0.36	0.1	0.1	0.8
III	0.07	0.3	0.4	0.3
IV	0.016	0.3	0.4	0.3
V	0.0028	0.5	0.3	0.2
VI	0.0011	0.7	0.2	0.1
VII	8.5E-5	0.8	0.1	0.1
VIII	1.5E-5	0.9	0.05	0.05

Release Fractions

Radionuclide release fractions were assumed to be the same from one alternative to another, which would be a conservative assumption because the inhalation of dispersed radionuclides would be the principal exposure pathway, and the fractions of respirable particles would be greatly reduced for waste treated thermally (Action Alternative 2). More realistic release fractions for thermally treated waste would have resulted in estimated accident impacts that were 1,000 times lower.

Radionuclide release fraction analysis in SEIS-I determined how much radioactive material could be released as respirable particulates after a very severe accident that affected the containment

capabilities of the shipping containers or casks. Because inhalation is the primary exposure pathway for TRU radionuclides, a mean aerodynamic diameter of less than 10 microns was used in the analysis. Larger particles would be trapped in mucus membranes, filtered, and expelled from the body before they could reach the lungs. This approach was consistent with existing NRC impact assessments (NRC 1977, 1987).

The following steps were used to calculate radionuclide release fractions for very severe accidents:

- Characterize the radioactive material being transported
- Identify and quantify breach of the shipping containers or casks due to accident conditions
- Identify and quantify the mechanisms by which radioactive material was released to the environment

SEIS-II analysis used representative parameter values where published data and test results are applicable and reasonable and conservative estimates where uncertainties exist.

To characterize the radioactive material being transported, the radionuclides, quantities, and concentrations used in the analyses were based on waste inventory data and projections presented in Appendix A. DOE has established criteria and procedures that govern the physical, radiological, and chemical composition of TRU waste (DOE 1996). Physical restrictions require that the waste not be in a free-liquid form and that particulate waste be limited to specific levels. To estimate the impacts for radiological releases in a transportation accident, two radionuclide inventories were determined for both CH-TRU and RH-TRU waste shipments. One inventory was based on maximizing the radionuclide concentrations to the limit allowed in planning-basis WAC, the other was based on average radionuclide concentrations.

For the radiological inventory based on the planning-basis WAC, the PE-Ci activity was maximized using radionuclide-specific weighting factors. To obtain this correlation, the 50-year committed effective dose equivalent (CEDE) or dose conversion factor (DCF) for a unit intake of each radionuclide was used. DCFs were determined by the methodology described in International Commission on Radiological Protection (ICRP) Publications 26 and 30 (ICRP 1977 and CRP 1978). The radionuclide inventory was obtained by searching through BIR-2 site radionuclide inventories to find the limiting set of radionuclides for CH-TRU and RH-TRU waste.

To determine which site would have average radionuclide inventory, the individual radionuclide concentrations for each site were multiplied by 2.8 cubic meters (100 cubic feet) to obtain the radionuclide inventory per TRUPACT-II. This value was then multiplied by the radionuclide-specific inhalation DCF, expressed in rem per curie (Ci). The resulting doses were summed to get a measure of the relative inhalation hazard associated with each radionuclide inventory. The average radionuclide inventories were found to be at SRS (for CH-TRU waste) and Hanford (for RH-TRU waste).

The bounding (maximized) radionuclide inventory was determined by increasing the average inventories until one of the planning-basis WAC limits (DOE 1996) was reached. The goal was to increase the radionuclide activity up to the planning-basis WAC PE-Ci limit of 80 PE-Ci grams per drum while not exceeding the fissile gram limit of 200 grams per drum and 325 grams per TRUPACT-II or the thermal power limit of 40 watts per TRUPACT-II for untreated waste. For treated waste, the PE-Ci limit is 1,800 grams per drum, and the fissile gram and thermal power

limits are the same as for untreated waste. The average inventories for SRS and Hanford were increased by approximately a factor of four. The bounding radionuclide inventories for CH-TRU and RH-TRU waste are shown in Table E-17. When estimating a bounding case inventory for treated waste (Action Alternatives 2 and 3), however, increasing the PE-Ci amount beyond 80 grams per drum would violate planning-basis WAC thermal power or fissile gram equivalents limits. Therefore, the bounding radionuclide inventory for treated waste was not analyzed.

Table E-17
Bounding Case Radionuclide Inventories for CH-TRU and RH-TRU Waste Accidents[a]

Radionuclide	Adjusted Inventory CH-TRU (Curies per TRUPACT-II)	Adjusted Inventory RH-TRU (Curies per RH-72B)
Co-60	6.4E-4	2.5
Sr-90	0.01	49
Cs-137	0.01	49
U-233	---	0.03
U-235	---	1.0E-3
U-238	---	7.1E-5
Pu-238	990	1,000
Pu-239	16	20
Pu-240	4.2	10
Am-241	3.6	12
Pu-241	200	10
Pu-242	6.8E-4	---

[a] Dashes indicate radionuclides not found in the inventory.

For SEIS-II accident analysis, it was assumed that only one of the TRUPACT-IIs in the shipment would fail in an accident. This assumption was based on Fischer et al. (1987), which found that impact with a hard target, such as a bridge abutment, could potentially breach one TRUPACT-II container per shipment. While a fire of long duration engulfing three TRUPACT-IIs could result in the failure of one or more TRUPACT-IIs, the release fraction from three failed TRUPACT-IIs in such a fire is less than the release fraction from a single package from impact; therefore, the single failure from impact was assumed to be bounding.

Although catastrophic failures would be extremely unlikely, the accident analyses are consistent with the NRC's position (Fischer et al. 1987) and did not take credit for any processes that would reduce radioactive material releases (e.g., particle settlement, vapor plate-out on interior or exterior surfaces, filtration effects along leak path). The immediate release of radioactive material from impact events and the delayed release of radioactive material from fire were assumed; however, TRU waste containers were not assumed to fail from impact until an accident of severity category V was reached. A failure threshold corresponding to severity category III (an accident with conditions slightly exceeding the NRC's test requirements) was conservatively assumed for a fire.

Normally, any release of radioactive material due to a transportation accident would progress in two stages; release inside the shipping containers or casks followed by release to the environment. It was assumed, without regard to waste form or type, that all failed waste containers release an average amount of material for each accident severity category.

In assessing releases from impact events, the following steps were used:

- Identification of the fraction of failed waste containers inside the shipping container or cask
- Determination of the fraction of radioactive material released from failed waste containers
- Calculation of the fraction of radioactive material released from failed waste containers that would aerosolized in a respirable form by the mechanical stress of impact
- Calculation of the fraction of radioactive material released from failed waste containers that becomes aerodynamically entrained in a respirable form after the loss of containment and any subsequent depressurization (e.g., TRUPACT-II design pressure of 50 pounds per square inch gauge [psig])

The algorithm used to calculate the release fraction of respirable radioactive material from impact stresses is presented as Equation E-1:

$$IRF = (FFC)(FMRC)(FMPI)(FMAI + FMEI) \qquad \text{(Equation E-1)}$$

where

IRF	=	Impact release fraction
FFC	=	Fraction of failed waste containers
FMRC	=	Fraction of material released from failed containers into the package cavity
FMAI	=	Fraction of material aerosolized from impact
FMEI	=	Fraction of material entrained to environment during an impact event
FMRPI	=	Fraction of material released from package cavity during an impact event

Values for specific algorithm parameters are presented in Table E-18.

Fischer et al. (1987) estimated that 1.7 percent of truck accidents would involve fires. For fire, the following method was used for each accident severity category:

- Identification of the fraction of radioactive material subject to thermal release mechanisms
- Calculation of the fraction of radioactive material released in a respirable form by combustion
- Calculation of the fraction of radioactive material released in a respirable form by gases and the heating of contaminated surfaces
- Determination of the fraction of radioactive material released in a respirable form by volatilization of radionuclides

Table E-18
Impact Release Algorithm Parameters for CH-TRU and RH-TRU Waste Shipments

Parameters	Value	Basis/Reference
FFC	0.2728 lnF -2.814	(DOE 1990) where F is NRC (1977) accident severity breach force (Newtons)
FMRC	From columns below	(DOE 1990) and NRC (1977) used as guidance
FMAI	From columns below	(DOE 1990) resuspension factor of 2.00×10^{-2} m^{-1} used (mechanical stress of vigorous sweeping)
FMEI	1.50×10^{-4}	(DOE 1990) average entrainment value for 4 surfaces used with airflow of 2.5 mph for 30 minutes
FMRPI	Accident severity 1-4: 0.0 Accident severity 5-8: 1.0	Type B package design and NRC (1977) used as guidance

					TRUPACT-II		RH-72B Cask	
Severity Category	FMRC	FMAI	FMEI	FMRPI	FFC	IRF	FFC	IRF
I	0	0	0	0	0	0	0	0
II	0	0	0	0	0	0	0	0
III	0.1	8×10^{-5}	0	0	0.3	0	0.3	0
IV	0.3	8×10^{-5}	0	0	0.5	0	0.7	0
V	0.5	8×10^{-5}	1.5×10^{-4}	1	0.7	8×10^{-5}	1	1×10^{-4}
VI	0.7	8×10^{-5}	1.5×10^{-4}	1	1	2×10^{-4}	1	1×10^{-4}
VII	1	8×10^{-5}	1.5×10^{-4}	1	1	2×10^{-4}	1	2×10^{-4}
VIII	1	8×10^{-5}	1.5×10^{-4}	1	1	2×10^{-4}	1	2×10^{-4}

In the absence of detailed knowledge about the responses of shipping and waste containers to fires that are more severe than those specified in Type B packaging requirements, it was conservatively assumed that all radioactive material was available for release, for all accidents exceeding severity category II, as limited by the specific release mechanisms.

For combustion related releases, it was assumed that combustible materials could be ignited in all accident severity categories exceeding category II. The amount of oxygen present to support combustion was calculated by assuming a loaded shipping container has an 85 percent void volume and that there would be no external sources of air or oxygen (no major breach of container). The results of experiments conducted by Mishima and Schwendiman (DOE 1990) were used to assess the fraction of radioactive material released in a respirable form by the burning of combustible material.

Under accident severity categories IV through VIII, the fire may last longer than 1.5 hours. It was assumed, therefore, that more radioactive material could be converted to an aerosol because of the release of gases from the waste at elevated temperatures. Vaporization was considered as another potential release mechanism during a fire. Alexander et al. (DOE 1990) reports that volatile releases of TRU radionuclides are not of any significance until temperatures of 1,727 Celsius (°C) (3,140°Fahrenheit [°F]) are reached. It was concluded that potential accidents involving CH-TRU waste shipments cannot result in radioactive material releases in a vapor form.

The volatilization of uranium oxide becomes measurable at approximately 1,627°C (2,960°F). Flame temperatures pursuant to the open burning of hydrocarbon fuels (e.g., JP-4, gasoline, diesel) range from 760°C to 1,316°C (1,400°F to 2,400°F), with a median temperature of approximately 982°C (1,800°F). Consequently, a volatile release of material containing TRU radionuclides or uranium oxide would not be reasonably foreseeable for a transportation accident.

RH-TRU waste contains activation/fission products that may volatilize at elevated temperatures. Because the proportion of these products is uncertain, it was assumed that their release would be based on the values estimated for respirable particulate releases. The algorithm for estimating the respirable release fraction of radioactive material from thermal accident events is presented as follows:

$$TRF = (FAT)(FMRT)[(FMC)(FMAC) + (FMAT)] \qquad \text{(Equation E-2)}$$

where

TRF	=	Thermal release fraction
FAT	=	Fraction of accidents involving a thermal event
FMC	=	Fraction of material consumed by combustion
FMAC	=	Fraction of material aerosolized by combustion
FMAT	=	Fraction of material aerosolized by thermal event
FMRPT	=	Fraction of material released from the package cavity during a thermal event

Values for specific algorithm parameters are summarized in Table E-19.

The calculated release fractions from impact (Table E-18) and fires (Table E-19) were added to determine the total respirable release fractions due to very severe transportation accidents and are summarized in Tables E-20 and E-21 for CH-TRU and RH-TRU waste, respectively. A maximum release fraction of 2×10^{-4} was estimated for accidents involving both CH-TRU and RH-TRU waste shipments. This is consistent with or bounds previous transportation impact studies such as SEIS-I (DOE 1990) and the NRC modal study (Fischer et al. 1987), which estimated particulate releases of 2×10^{-6} and vapor (C_s) releases of 2×10^{-4} due to spent fuel shipments.

Atmospheric Dispersion and Exposure Pathways

The dispersion of airborne radioactive material during an accident is dependent on meteorologic conditions at the time of the accident. Airborne radioactive material moves downwind from the scene of the accident; its dispersal and transport are affected by the degree of atmospheric turbulence. Large areas may be affected. The degree of dispersion is influenced by factors, such as the season (which influences atmospheric turbulence), time of day, degree of cloud cover, wind speed, land surface features and characteristics, and other meteorologic parameters.

RADTRAN or similar analytical tools can be used to evaluate the impacts of radioactive material released under transportation-accident conditions. Exposure pathways must be identified and the size of exposed populations must be estimated for input to RADTRAN. Transportation accidents may be divided into two categories: those accidents in which the shipping containers maintain their integrity (no release of radioactive material) and those accidents in which the integrity of the shipping containers is compromised. The exposure pathways and the exposed population subgroups are discussed below.

Table E-19
Thermal Release Algorithm Parameters for CH-TRU and RH-TRU Waste Shipments

Parameter	Value	Basis/Reference
FAT	1.7×10^{-2} (Truck)	Fischer et al. (1987)
FMC	Accident severity I and II: 0	No internal combustion
	Accident severity III and IV: 9×10^{-4} (TRUPACT-II) 7×10^{-4} (RH-72B Cask)	Type B package design Limited internal oxygen source: 3.95 lb O_2 (TRUPACT-II) 0.73 lb O_2 (RH-72B)
FMAC	Accident severity I and II: 0 Accident severity III - VIII: 5×10^{-4}	Type B package design Mishima and Schwendiman (DOE 1990)
FMAT	Accident severity I and II: 0	Type B package design
	Accident severity III: 2×10^{-8}	Only combustion assumed to occur, with attendant off-gas (combustion) products
	Accident severity IV - VIII: 1×10^{-5} (TRUPACT-II) 9×10^{-6} (RH-72B Cask)	Off-gassing assuming steam/graphite reaction and resuspension factor of 5.0×10^{-6} meter^{-1} corresponding to a surface stress from walking (DOE 1990)
FMRPT	Accident severity I and II: 0 Accident severity III - VIII: 1	Type B package design NRC (1977) used as guidance

Severity Category	FMAC	FMAC	FMAT	FMRPT	FAT	TRF
TRUPACT-II						
I	0	0	0	0	0.02	0
II	0	0	0	0	0.02	0
III	9×10^{-4}	5×10^{-4}	2×10^{-8}	1	0.02	8×10^{-9}
IV	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
V	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
VI	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
VII	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
VIII	9×10^{-4}	5×10^{-4}	1×10^{-5}	1	0.02	2×10^{-7}
RH-72B Cask						
I	0	0	0	0	0.02	0
II	0	0	0	0	0.02	0
III	7×10^{-4}	5×10^{-4}	2×10^{-8}	1	0.02	6×10^{-9}
IV	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}
V	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}
VI	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}
VII	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}
VIII	7×10^{-4}	5×10^{-4}	9×10^{-5}	1	0.02	2×10^{-7}

Table E-20
CH-TRU Waste Truck Transportation Release Fractions

Total Respirable Release Fraction (TRRF) = Impact Release Fraction (IRF) + Thermal Release Fraction (TRF)			
Accident Severity Category	**IRF[a]**	**TRF[b]**	**TRRF**
I	---	---	---
II	---	---	---
III	---	8×10^{-9}	8×10^{-9}
IV	---	2×10^{-7}	2×10^{-7}
V	8×10^{-5}	2×10^{-7}	8×10^{-5}
VI	2×10^{-4}	2×10^{-7}	2×10^{-4}
VII	2×10^{-4}	2×10^{-7}	2×10^{-4}
VIII	2×10^{-4}	2×10^{-7}	2×10^{-4}

[a] From Table E-18
[b] From Table E-19

Table E-21
RH-TRU Waste Truck Transportation Release Fractions

Total Respirable Release Fraction (TRRF) = Impact Release Fraction (IRF) + Thermal Release Fraction (TRF)			
Accident Severity Category	**IRF[a]**	**TRF[b]**	**TRRF**
I	---	---	---
II	---	---	---
III	---	6×10^{-9}	6×10^{-9}
IV	---	2×10^{-7}	2×10^{-7}
V	1×10^{-4}	2×10^{-7}	1×10^{-4}
VI	1×10^{-4}	2×10^{-7}	1×10^{-4}
VII	2×10^{-4}	2×10^{-7}	2×10^{-4}
VIII	2×10^{-4}	2×10^{-7}	2×10^{-4}

[a] From Table E-18
[b] From Table E-19

In an accident in which shipping containment is not breached, the only exposure pathway would be direct, external radiation from the intact package. The radiation dose to any member of an exposed population would be evaluated in the same manner as the exposure from normal (accident-free) transportation; adjustments would be made for the duration of exposure and the distance between the shipment and the exposed individuals. Potentially exposed populations include the truck crew, the occupants of the other vehicle(s) involved in the accident, bystanders/pedestrians, the occupants of nearby buildings, and emergency response crews.

In an accident that results in a failure of the shipping containers and the possible release of radioactive material, radiation exposures may result from both nondispersible and dispersible material. The exposure pathway from accidents involving shipping containers with nondispersible material would be direct, external radiation. Certain radioactive material forms are not dispersible because of their chemical or physical form (e.g., irradiated steel hardware); these materials may

nevertheless expose individuals to penetrating radiation. The radiation doses received by exposed individuals would be evaluated in the same manner as other direct exposures. Adjustments would be made for the increased dose rates that result from a loss of shielding, as well as exposure time and distances. The exposed populations would be the same as those identified above.

According to SEIS-I (DOE 1990), there are four potential exposure pathways from accidents that could cause a release of dispersible radioactive materials:

- Cloudshine would be the pathway of direct *external* dose from the passing cloud of dispersed radioactive material. Dispersion depends on the meteorologic conditions at the accident scene, the fraction of failed shipping containers, and the fraction of released material that becomes airborne.

- Groundshine would be the pathway of direct *external* dose from material that has deposited on the ground after being dispersed from the accident site.

- Inhalation would be the pathway of intake of respirable radioactive material that may result in internal radiation doses. Doses from inhalation depend on the fraction of failed shipping containers, the fraction of airborne material, the aerosol fraction of respirable size, the dilution factor for radioactive material in the surrounding air, the breathing rate of the exposed individual, and the radiation dose per curie of radionuclide inhaled.

- Resuspension would be a secondary inhalation pathway that exists when radioactive material that was dispersed and deposited is disturbed, becomes airborne, and is inhaled. Radiation dose assessment of this pathway would require combining the mechanisms of dispersion, deposition, and inhalation, as well as estimating the fraction of deposited material that is resuspended. Resuspension may result from changes in wind speed or direction or from disturbing deposited material by other means, such as traffic through a deposition area.

The estimated population doses were calculated using a resuspension particle half-life of 365 days. The resuspension half-life is the time required for half of the initially deposited material to be removed from the accessible environment. A resuspension half-life of 365 days would be extremely conservative given the washing (rain) and weathering (wind) processes that would serve to remove contaminants from the accessible environment. Because inhalation of resuspended particles would be a primary contributor to the estimated population dose, this conservative value was chosen. The assumed population density would also affect the total calculated dose and estimated health effects.

Exposure by ingestion was not included in evaluation of the radiological impacts of accidents. It was assumed that emergency response and governmental authorities would intervene to impound contaminated foodstuffs, provide an alternative water supply, and clean up contaminated land. The bounding accident was assumed to occur in an urban area to maximize the exposed population, which eliminates the ingestion pathway.

The population subgroups that would be exposed by an accident that results in the dispersion of radioactive material include the individuals directly exposed at the scene of the accident and individuals present in the areas over which dispersion would occur.

E.4.2.2 Radiological Impact Results for Transportation Accident Analyses

The radiological consequences of truck transportation accidents were apportioned among the eight severity categories, each of which is associated with a release fraction and a likelihood of occurrence and calculated for truck transportation. No release was assumed for accidents assigned to severity category I or II.

No releases from crush impacts were assumed for accidents below severity category VI. Releases from the TRUPACT-II were assumed to be possible during accidents involving fires in category III or above. Release fractions for each severity category were combined with the accident rates for each category, the probability of a fire or impact, the travel distance per shipment, the total number of shipments, and the travel fraction through each population density zone to determine an aggregate, probability-weighted consequence.

The results of the analyses of aggregate radiological impacts due to severe transportation accidents are presented by origination site in Table E-22. The sum of the consequences was multiplied by the likelihood of occurrence for the eight accident severity categories to estimate the impacts. Site-specific information and the bounding case radionuclide inventory for untreated waste were used. Although there are different release fractions for untreated, thermally treated, and shred and grout treated waste, the untreated release fractions were used to determine population doses in order to bound the impacts.

E.4.3 Radiological Consequences of Bounding-Case Transportation Accidents

Bounding-case transportation accident scenarios were used to calculate the impact of very severe accidents (category VIII) in higher population areas (urban) along designated transportation routes. Accidents were postulated and analyzed for both CH-TRU and RH-TRU waste shipments. Both the average and the bounding radionuclide inventories were used in these analyses.

E.4.3.1 Assumptions for Bounding-Case Transportation Accidents

The assumptions made regarding the bounding-case transportation accident scenarios are as follows:

- Impacts were analyzed without regard to the likelihood of the accident actually occurring.
- The waste shipment would be three fully-loaded TRUPACT-IIs on a combination tractor-trailer truck. Two types of inventories were considered for the bounding case accident. One was based on the average concentrations of radionuclides. The second was chosen to maximally bound the impacts by loading the TRUPACT-II up to the planning-basis WAC limit.
- Accidents were severity category VIII.
- All waste was packaged in Type A drums.
- A minor breach occurred, limiting external oxygen sources.
- A 0.02 percent fraction of the radioactive waste material was released to the environment in a respirable form (less than 10 microns in diameter).

Table E-22
Aggregate Radiological Impacts from Severe Accidents (person-rem) [a, b, c]

Impacts from Accidents	Proposed Action-Scaled to WIPP Max	Action Alternative 1			Action Alternative 2A			Action Alternative 2B			Action Alternative 2C		
	Basic Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste													
Argonne National Laboratory-East	1 (5.0E-4)	0.8 (4.0E-4)	---	0.8 (4.0E-4)	---	---	---	---	---	---	0.7 (3.5E-4)	---	0.7 (3.5E-4)
Hanford Site	590 (0.3)	500 (0.3)	310 (0.2)	810 (0.5)	355 (0.2)	110 (0.06)	465 (0.2)	355 (0.2)	110 (0.06)	465 (0.2)	500 (0.3)	310 (0.2)	810 (0.5)
Idaho National Engineering Laboratory/ANL-W	155 (0.08)	130.1 (0.07)	175 (0.09)	305 (0.2)	110 (0.06)	96 (0.05)	210 (0.1)	220 (0.1)	110 (0.06)	330 (0.2)	130 (0.07)	180 (0.09)	310 (0.2)
Lawrence Livermore National Laboratory	3 (1.5E-3)	3 (1.5E-3)	---	3 (1.5E-3)	---	---	---	---	---	---	3 (1.5E-3)	---	3 (1.5E-3)
Los Alamos National Laboratory	7 (3.5E-3)	6 (3.0E-3)	2 (1.0E-3)	8 (4.0E-3)	4 (2.0E-3)	0.7 (3.5E-4)	5 (2.5E-3)	---	---	---	6 (3.0E-3)	2 (1.0E-3)	8 (4.0E-3)
Mound Plant	2 (1.0E-3)	2 (1.0E-3)	---	2 (1.0E-3)	---	---	---	---	---	---	2 (1.0E-3)	0.1 (5.0E-5)	2 (1.0E-3)
Nevada Test Site	1 (5.0E-4)	1 (5.0E-4)	---	1 (5.0E-4)	---	---	---	---	---	---	1 (5.0E-4)	---	1 (5.0E-4)
Oak Ridge National Laboratory	6 (3.0E-3)	5 (2.5E-3)	1.0 (5.0E-4)	6 (3.0E-3)	---	---	---	---	---	---	5 (2.5E-3)	0.2 (1.0E-4)	5 (2.5E-3)
Rocky Flats Environmental Technology Site	16 (8.0E-3)	14 (7.0E-3)	---	14 (7.0E-3)	7 (3.5E-3)	---	7 (3.5E-3)	---	---	---	14 (7.0E-3)	---	14 (7.0E-3)
Savannah River Site	48 (0.02)	41 (0.02)	12 (6.0E-3)	53 (0.03)	44 (0.02)	5 (2.5E-3)	49 (0.02)	44 (0.02)	5 (2.5E-3)	49 (0.02)	41 (0.02)	12 (6.0E-3)	53 (0.03)
RH-TRU Waste													
Hanford Site	8 (4.0E-3)	125 (0.06)	4 (2.0E-3)	130 (0.07)	47 (0.02)	3 (1.5E-3)	50 (0.03)	47 (0.02)	3 (1.5E-3)	50 (0.03)	47 (0.02)	3 (1.5E-3)	50 (0.03)
Idaho National Engineering Laboratory/ANL-W	5 (2.6E-3)	5 (2.5E-3)	1 (5.0E-4)	6 (3.0E-3)	---	---	---	---	---	---	---	---	---
Los Alamos National Laboratory	0.03 (1.5E-5)	0.03 (1.5E-5)	0.01 (5.0E-6)	0.04 (2.0E-5)	---	---	---	---	---	---	---	---	---
Oak Ridge National Laboratory	2 (1.0E-3)	9 (4.5E-3)	5 (2.5E-3)	14 (7.0E-3)	3 (1.5E-3)	2 (1.0E-3)	5 (2.5E-3)	3 (1.5E-3)	2 (1.0E-3)	5 (2.5E-3)	3 (1.5E-3)	2 (1.0E-3)	5 (2.5E-3)
Total CH-TRU and RH-TRU Waste	850	840	510	1350	570	220	790	670	230	900	760	510	1270
Total LCFs	0.4	0.5	0.3	0.8	0.3	0.1	0.4	0.3	0.1	0.4	0.4	0.3	0.7

[a] Mathematically expected LCFs are in parentheses.
[b] Total values may differ due to rounding.
[c] Dashes indicate that there would be no shipments to WIPP.

Table E-22
Aggregate Radiological Impacts from Severe Accidents (person-rem)-Continued [a, b, c]

Impacts from Accidents	Action Alternative 3			No Action Alternative 1A			No Action Alternative 1B		
	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory	Basic Inventory	Additional Inventory	Total Inventory
CH-TRU Waste									
Argonne National Laboratory-East	---	---	---	0.7 (3.5E-4)	---	0.7 (3.5E-4)	0.7 (3.5E-4)	---	0.7 (3.5E-4)
Hanford Site	1100 (0.6)	370 (0.2)	1500 (0.8)	---	---	---	---	---	---
Idaho National Engineering Laboratory/ANL-W	280 (0.1)	210 (0.1)	490 (0.2)	---	---	---	---	---	---
Lawrence Livermore National Laboratory	---	---	---	2.7 (1.3E-3)	---	2.7 (1.3E-3)	2.7 (1.3E-3)	---	2.7 (1.3E-3)
Los Alamos National Laboratory	10 (5.0E-3)	3 (1.5E-3)	13 (6.5E-3)	---	---	---	5.7 (2.9E-3)	2.1 (1.1E-3)	7.8 (4.0E-3)
Mound Plant	---	---	---	1.8 (9.0E-4)	0.1 (5.4E-5)	1.9 (9.5E-4)	1.8 (9.0E-4)	0.1 (5.4E-5)	1.9 (9.5E-4)
Nevada Test Site	---	---	---	1 (5.0E-4)		1 (5.0E-4)	1 (5.0E-4)	---	1 (5.0E-4)
Oak Ridge National Laboratory	---	---	---	4.7 (2.4E-3)	0.2 (1.0E-4)	4.9 (2.5E-3)	4.7 (2.4E-3)	0.2 (1.0E-4)	4.9 (2.5E-3)
Rocky Flats Environmental Technology Site	19 (0.01)	---	19 (0.01)	---	---	---	13.6 (6.8E-3)	---	13.6 (6.8E-3)
Savannah River Site	62 (0.03)	15 (7.5E-3)	77 (0.04)	---	---	---	---	---	---
RH-TRU Waste									
Hanford Site	160 (0.08)	8 (4.0E-3)	170 (0.09)	---	---	---	---	---	---
Idaho National Engineering Laboratory/ANL-W	6 (3.0E-3)	1 (5.0E-4)	7 (3.5E-3)	1.8 (9.0E-4)	0.6 (3.0E-4)	2.4 (1.2E-3)	1.8 (9.0E-4)	0.6 (3.0E-4)	2.4 (1.2E-3)
Los Alamos National Laboratory	0.04 (2.0E-5)	0.02 (1.0E-5)	0.06 (3.0E-5)	0.01 (5.0E-6)	5.4E-3 (2.7E-6)	0.02 (7.7E-6)	0.01 (5.0E-6)	5.4E-3 (2.7E-6)	0.02 (7.7E-6)
Oak Ridge National Laboratory	10 (5.0E-3)	6 (3.0E-3)	16 (8.0E-3)	---	---	---	---	---	---
Total CH-TRU and RH-TRU Waste	1700	610	2300	12.7	0.9	13.6	32	3	35
Total LCFs	0.9	0.3	1.2	6.3E-3	4.5E-4	6.8E-3	0.02	1.5E-3	0.02

[a] Mathematically expected LCFs are in parentheses.
[b] Total values may differ due to rounding.
[c] Dashes indicate that there would be no shipments to WIPP.

Note: Shipments for No Action Alternative 1A and 1B are the number of shipments to consolidate TRU waste. No TRU waste would be shipped to WIPP.

- Radioactive material was evenly distributed throughout the waste volume.
- Accidents occurred in the urban portion of a nonspecific, large metropolitan area (population greater than one million) with a mean population density of 3,861 persons per square kilometer.
- Accidents occurred during very stable meteorlogic conditions, limiting dispersion of the radioactive material plume and maximizing radiation doses.
- In the accident scenarios involving truck transportation, one TRUPACT-II or RH-72B was breached and subsequently engulfed in fire for two hours.
- In the accident scenarios involving rail transportation, two TRUPACT-IIs or RH-72Bs were breached and subsequently engulfed in fire for two hours.
- Doses were calculated using a resuspension particle half-life of 365 days.

For the CH-TRU waste bounding accident, the radionuclide activity, curies per TRUPACT-II, was increased to reach the planning-basis WAC limit for both PE-Ci and fissile gram equivalents. This increased the amount of Pu-238 in a TRUPACT-II by approximately an order of magnitude. Due to the low likelihood of encountering very stable atmospheric conditions, a bounding radionuclide inventory, and the large population densities, radiological doses are likely to be considerably lower than the calculated values.

For the RH-TRU waste bounding accident, the amount of Pu-238 and Pu-239 was increased by factors of 1,000 and 10, respectively. This was done to maximize the consequences of an accident to both the population and the MEI. Based on reported radionuclide inventories from each site, actual doses from an accident would be expected to be an order of magnitude lower.

E.4.3.2 Impact Results for Bounding-Case Transportation Accident Analyses

Because it was assumed that the accidents occurred in an urban area, impacts from the ingestion of contaminated agricultural products were not applicable. Population and MEI doses were calculated by RADTRAN.

No early fatalities or morbidities were estimated. Inhalation (initial or resuspension) was the dominant contributor to radiation doses. The impacts associated with the bounding-case accidents would be as follows:

- For the bounding inventory in a breached TRUPACT-II, the total population dose was estimated to be 31,800 person-rem, resulting in 16 LCFs in the exposed population. The estimated dose to the MEI would be 123 rem total effective dose equivalent (TEDE), resulting in a 6 percent chance of a cancer fatality.
- For the bounding inventory in a breached RH-72B, the total population dose was estimated to be 32,500 person-rem, resulting in 16 LCFs in the exposure population. The MEI dose would be 125 rem (TEDE), resulting in a 6 percent chance of a cancer fatality.

- For the average radionuclide inventory in a breached TRUPACT-II, a total population dose of 6,370 person-rem was estimated. This would result in approximately 3 LCFs in the exposed population. The estimated MEI dose would be 80 rem (TEDE), resulting in a 4 percent chance of a cancer fatality.

- For the average radionuclide inventory in a breached RH-72B, the total population dose would be 72 person-rem, resulting in an expectation of 0.04 LCF in the population. The estimated MEI dose would be 1.4 rem (TEDE), resulting in a 0.07 percent chance of a cancer fatality.

The same bounding case accidents were analyzed for thermally treated TRU waste. The release fraction would be reduced by a factor of 1,000, however, thermal treatment increases the concentration of radionuclides by approximately a factor of 2.8. The combination of these two factors reduces the overall radiological impacts from bounding case accidents for thermally treated waste. The impacts would be as follows:

- For the bounding radionuclide inventory in a breached TRUPACT-II, the total population dose resulted in 0.09 LCFs in the exposed population. The estimated MEI dose resulted in a 0.03 percent chance of a cancer fatality.

- For the bounding radionuclide inventory in a breached RH-72B, the total population dose resulted in 0.09 LCFs in the exposure population. The estimated MEI dose resulted in a 0.03 percent chance of a cancer fatality.

- For the average radionuclide inventory in a breached TRUPACT-II, approximately 0.02 LCFs in the exposed population would be expected. The estimated MEI dose resulted in a 0.02 percent chance of a cancer fatality.

- For the average radionuclide inventory in a breached RH-72B, the total population dose resulted in an expectation of 2×10^{-4} LCFs in the population. The estimated MEI dose resulted in a 4×10^{-4} percent chance of a cancer fatality.

E.5 HAZARDOUS CHEMICAL IMPACTS FROM TRANSPORTATION ACCIDENTS

This section evaluates the impacts associated with exposures to hazardous chemicals during the transportation of TRU waste to WIPP. Hazardous chemicals in TRU mixed waste occur as volatile organic compounds (VOC) and metals. Accidents involving hazardous chemicals and metals are evaluated as acute-release events with respect to potential exposures and associated impacts.

During accident-free transportation, exposure to hazardous chemicals and metals would be unlikely because the hazardous chemical components in the waste are completely contained in the transportation container/cask. Thus, no impacts to human health are posed by the hazardous chemical components under accident-free transportation.

The analyses used to assess impacts from hazardous chemicals exposures during transportation accidents was based on those in SEIS-I (DOE 1990).

E.5.1 Methodology

Hazardous material inventories were developed as described in Appendix A. For those VOCs where maximum levels are stipulated in the planning-basis WAC, those levels were assumed to be in the containers/casks being transported during an accident. Where no maximum level was specified in planning-basis WAC, the highest level found during waste drum sampling was selected to ensure that the typical concentration would be bounded. Details on the metal inventory can be found in Appendix A.

Because a TRUPACT-II is likely to hold nearly three times the waste volume with hazardous chemicals than an RH-72B would hold, it was assumed that CH-TRU waste hazardous chemical accident scenarios would bound any impacts from RH-TRU waste. Therefore, no hazardous chemical accidents were analyzed for RH-TRU waste shipments. For the purposes of analyses, it was assumed that the RH-TRU hazardous chemical inventory would be the same as the CH-TRU hazardous chemical inventory.

Although the likelihood that a TRUPACT-II would be breached is low, such an accident would be foreseeable and constitute a source of potential hazardous chemical exposures. The hazardous chemical assessment was conservatively based on a very severe transportation accident. It was assumed that an accident would result in the breach of one of three TRUPACT-IIs and in a fire engulfing all three. This bounding-case accident scenario was also based on the assumption that the entire releasable fraction of each chemical considered was used. Whenever possible, the assumptions used in the radiological accident assessment provide the basis for the impacts of accidents involving the chemical components of the waste. The hazardous chemical impact was compared to the maximum airborne chemical concentrations for a member of the public and the immediately dangerous to life or health (IDLH) values. Ratios smaller than one were considered to have no noncarcinogenic impact.

Based on a 30-minute exposure period and an individual who inhales 10 cubic meters (353 cubic feet) of contaminated air, the IDLHs were originally developed by the National Institute of Occupational Safety and Health (NIOSH) for emergency response purposes. The IDLH-equivalent intake level is the quantity of material inhaled during 30 minutes of exposure. The hazardous constituents analyzed for these accident scenarios and the IDLH values and IDLH-equivalent intake values are shown in Table E-23.

The following assumptions were used to maximize the hazardous chemical concentrations within the breached TRUPACT-II:

- Nonflammable VOCs with planning-basis WAC-prescribed limits (carbon tetrachloride, chloroform, and methylene chloride) were assumed to be at those limits.
- Flammables were assumed to have a maximum concentration of 500 parts per million because they are limited to that in planning-basis WAC.
- VOCs without planning-basis WAC limits were assumed to be present at the maximum concentrations identified to date during sampling of CH-TRU waste.

Table E-23
Chemical Constituents Analyzed in CH-TRU Waste

Chemical Name	IDLH (parts per million)	IDLH (milligrams per cubic meter)
Carbon Tetrachloride	200	1,278
Chloroform	500	2,480
Methylene Chloride	2,300	8,119
1,1,2,2-Tetrachloroethane	100	700
Chlorobenzene	1,000	4,680
Methyl Ethyl Ketone	3,000	9,000
Toluene	500	1,915
1,2 Dichloroethane	50	206
Beryllium	N/A	4
Cadmium	N/A	9
Lead	N/A	100
Mercury	N/A	10

N/A = Not applicable

- Hazardous metals (lead, mercury, beryllium, and cadmium) were assumed to be uniformly mixed in the waste container and found in the containers in average amounts (see Appendix A). Metals would be released as particulates; therefore, the calculations used to determine the radioactive material particulate releases were applied to these as well.

Carbon tetrachloride, trichloroethylene, and methylene chloride are considered potential carcinogens by the EPA, and 1,1,1-trichloroethane may produce adverse somatic effects. Lead is the most abundant metal found in the waste by both weight and volume (DOE 1996).

Despite the fact that a fire would destroy virtually all waste VOCs, it was conservatively assumed that VOCs were released from the breached TRUPACT-II in their entirety. The air concentrations of each hazardous chemical for the maximally exposed member of the public at the scene of the accident were determined using the Gaussian dispersion plume equation of Pasquill, as modified (DOE 1995c). Ground-level concentrations were calculated at the centerline of the plume.

Plume depletion effects from particulate settlement (by gravitational or chemical effects) were not considered. Therefore, air concentrations and the resulting intakes by inhalation were overestimated for particulate metals but not for VOCs. Additionally, each accident was postulated to occur during a period of very stable meteorologic conditions (Pasquill Stability Class F, wind speed of 1 meter per second) to introduce additional conservatism into the analyses.

The effective height of the plume from the accident was estimated to be approximately 21 meters (69 feet), which would account for the buoyancy rise associated with the thermal effects from the accident. The maximum airborne chemical concentration inhaled by a member of the public was calculated as the following:

$$Ar = \left(\frac{E}{Q}\right) R \qquad \text{(Equation E-3)}$$

where

Ar = Air concentration at the location of the least plume dispersion (maximum impact)

E/Q = Dispersion estimate, 1.13×10^{-4} second per cubic meter

R = Hazardous chemical release rate over the assumed 7,200-second release period in milligrams per second

E.5.2 Results

Hazardous chemical impacts were evaluated for a bounding, severity category VIII accident (likelihood of occurrence of 1×10^{-6}). The MEI (receptor) was assumed to be located 1,000 meters (3,300 feet) downwind from the accident, exposed at the centerline of the plume for two hours under very stable meteorologic conditions and low wind speed. The hazardous chemicals analyzed and the impacts to the MEI as a fraction of the chemical-specific IDLH value are presented in Table E-24. For all chemicals analyzed, the concentration to which the MEI would be exposed would be no more than approximately 1.1×10^{-4} (for 1,2-dichloroethane) of the chemical's IDLH value. Therefore, no human health effects would be expected from acute exposure to hazardous chemicals released from a severe transportation accident.

Table E-24
Chemical Airborne Releases for a Severity Category VIII Accident
(CH-TRU Waste Truck Shipment)

Chemical	Quantity (milligrams per cubic meter)	Quantity (milligrams)	Release Rate[a] (milligrams per second)	Maximum Receptor Air Concentration (milligrams per cubic meter)[b, c]	Concentration per IDLH Value
Carbon Tetrachloride	6.6E+5	9.3E+5	260	0.03	2.3E-5
Chloroform	4.3E+5	6.1E+5	170	0.02	7.7E-6
Methylene Chloride	1.8E+7	2.5E+7	7.0E+3	0.8	9.7E-5
1,1,2,2-Tetrachloroethane	4.2E+5	5.9E+5	160	0.02	2.6E-5
Chlorobenzene	2.8E+5	3.9E+5	110	0.01	2.6E-6
Methyl Ethyl Ketone	1.6E+6	2.3E+6	630	0.07	7.9E-6
Toluene	3.7E+5	5.2E+5	140	0.02	8.5E-6
1,2 Dichloroethane	5.2E+5	7.2E+5	200	0.02	1.1E-4
Beryllium	340	94	0.13	1.5E-5	3.7E-6
Cadmium	4.8	1.4E+4	1.9E-3	2.1E-7	2.4E-8
Lead	1.3E+4	37	5.2	5.9E-4	5.9E-6
Mercury	5.7E+3	16	2.2	2.5E-4	2.5E-5

[a] Release rate = Release fraction x quantity of hazardous constituent present in a single TRUPACT-II x 1/7200 seconds x Quantity Released
[b] The receptor is the public MEI
[c] Receptor Concentration = E/Q' (max individual) x release rate (milligrams per second); = 1.13×10^{-04} (seconds/cubic meter) x Release Quantity (milligrams) / 7200 seconds; assumes a two hour release.

E.6 IMPACTS FROM TRU WASTE SITES CONSOLIDATING AT MAJOR GENERATOR-STORAGE SITES

The preceding sections address the impacts of transporting TRU waste from the consolidation or treatment sites to WIPP. These impacts were used to estimate the impacts of shipping TRU waste from a small quantity site to one of the consolidation or treatment sites based on the total miles traveled. Also included in this section are the impacts of transporting waste from the 10 major generator-storage sites under Action Alternative 2 and Action Alternative 3, and No Action Alternatives 1A and 1B (Table E-25) which do not treat their waste. Table E-26 presents the total one-way miles for the Proposed Action and alternatives for shipment of TRU waste from large quantity sites. The waste is consolidated and treated at one of the sites from the list of the 10 major generator-storage sites and then the treated waste is shipped to WIPP.

Table E-25
Transportation Impacts for Consolidation of Waste from Major Generator-Storage Sites

Impact Category	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B
Nonradiological Impacts						
Emission-related LCFs	4.8E-3	0.03	3.8E-3	0.01	1.1E-4	8.0E-3
Vehicle Related Fatalities	0.2	1.1	0.1	0.5	4.8E-3	0.2
Accident-free Radiological Impacts						
Occupational (person-rem)	13	160	7.7	31	0.3	32
Nonoccupational (person-rem)	200	1.0E+3	160	550	5.4	190
Occupational (LCFs)	5.2E-3	0.06	3.1E-3	0.01	1.1E-4	0.01
Nonoccupational (LCFs)	0.1	0.5	0.08	0.3	2.7E-3	0.1

Table E-26
Truck Mileages for the Consolidation of CH-TRU and RH-TRU Waste from Major Generator Sites to Treatment Sites

Alternatives	CH-TRU Total One-way Mileage	RH-TRU Total One-way Mileage
Proposed Action	---	---
Action Alternative 1	---	---
Action Alternative 2A	300,000	1,200,000
Action Alternative 2B	8,500,000	1,200,000
Action Alternative 2C	---	---
Action Alternative 3	450,000	3,800,000
No Action Alternative 1A	300,000	1,200,000
No Action Alternative 1B	8,500,000	1,200,000

Table E-27 presents the total one-way miles under the Proposed Action and the alternatives for the shipment of TRU waste from the small quantity sites to the consolidation sites. Chapter 3 provides the details of the consolidation. The mileage in this table along with the total miles for shipments to WIPP were used to adjust the impact results estimated for the consolidation/treatment sites. As shown in Table E-28, the impacts from the small quantity sites is a small fraction of the impacts of transportation to WIPP.

Table E-27
Truck Mileages for the Consolidation of CH-TRU and RH-TRU Waste from Small Quantity Sites

Alternatives	CH-TRU Total One-way Mileage	RH-TRU Total One-way Mileage
Proposed Action	16,000	390,000
Action Alternative 1	35,000	2,570,000
Action Alternative 2A	43,000	900,000
Action Alternative 2B	47,000	900,000
Action Alternative 2C	94,000	900,000
Action Alternative 3	59,000	3,090,000
No Action Alternative 1A	43,000	900,000
No Action Alternative 1B	47,000	900,000

E.7 TRANSPORTATION IMPACTS FROM REGULAR AND DEDICATED RAIL SHIPMENTS

This section presents a summary of transportation impacts for both regular rail and dedicated rail. Transportation by rail could be conducted from eight of the 10 major generator-storage sites. Truck shipments would be used from the sites with only small amounts of waste and from those sites without rail spurs.

The impacts presented in this section were determined by adjusting the transportation impacts from truck shipments. This approach was feasible because many previous studies have performed detailed truck and detailed rail analyses (DOE 1994). These studies provided a firm basis for adjusting the rail impacts.

DOE would need to address several issues in conjunction with a decision to use rail transportation. These issues would include the following:

- The DOE trucking contractor has hired and trained drivers and would be responsible for procuring and maintaining vehicles and packagings for transporting the TRU waste. Over the last several years, all communities on highway transportation routes specified in SEIS-I were offered emergency response training. Similar development or planning has not been accomplished for rail.

Table E-28
Small Quantity Sites Transportation Impacts Relative to Major Generator-Storage Site Transportation Risk

Impact Category	Proposed Action	Action Alternative 1	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C	Action Alternative 3	No Action Alternative 1A	No Action Alternative 1B	No Action Alternative 2
Nonradiological Risk									
Emisson-related LCFs	1.3E-3	8.4E-3	3.0E-3	3.0E-3	3.2E-3	0.01	6.8E-5	1.1E-4	1.3E-3
Vehicle-related Fatalities	0.05	0.3	0.1	0.1	0.1	0.4	3.4E-3	4.7E-3	0.05
Incident-free Radiological Risk									
Occupational	2.8	17	6.6	6.6	7.6	20	0.2	0.4	2.8
Nonoccupational	55	360	130	130	130	410	3.9	4.9	55
Occupational (LCFs)	1.1E-3	6.9E-3	2.6E-3	2.6E-3	3.0E-3	8.1E-3	7.5E-5	1.4E-4	1.1E-3
Nonoccupational (LCFs)	0.03	0.2	0.06	0.06	0.07	0.2	1.9E-03	2.4E-3	0.03

- Regular rail is traditionally slower than highway, therefore, the NRC may need to allow a longer total shipping period than the 60-day truck limit. This could result in a reduction of the allowable TRUPACT-II loading to meet gas generation limits. Discussions between DOE, the NRC, and railroad industry personnel have not taken place.

- Discussions with railroad personnel regarding the use of regular train service or the safety requirements on dedicated trains have not been finalized. Thus, there is greater uncertainty surrounding rail transportation of TRU waste.

- Although projections of rail costs can be made, they are not based on a negotiated contract.

- Currently, there are no agreements in place for the tariffs for transporting TRU waste by rail from the major generator sites. This will require the coordination of a number of rail lines, depending upon the route traveled, and the coordination of the states and cities through which TRU waste would travel.

- In the event of an accident, a rail line could be disabled during the accident investigation, with the possibility of no alternative routing for both WIPP and non-WIPP related rail shipments.

- The emergency response preparedness and training would need to be addressed in those areas possibly affected by rail transportation.

E.7.1 Fatal Accident Rates

Rail accident statistics typically include the number of trains and the number of accidents and fatalities. The statistics do not include information concerning the number of fatalities per rail car. As with truck transportation, a commercial train is just as likely to be in an accident whether it hauls TRU waste or not. The average number of rail cars per train is 70. Therefore, when a train of 70 cars is in an accident that results in one death, that fatality would be represented as 1/70th of a fatality for each rail car. If that train included three rail cars of TRU waste, the fatality would only result in 3/70ths of a fatality statistically.

There are no statistics for the average number of cars in dedicated trains. It was assumed, therefore, that each dedicated train would have only three rail cars and that each rail car would be carrying TRU waste. Should a dedicated train be involved in an accident that results in a fatality, that fatality would be statistically apportioned as one-third a fatality for each rail car. This number could be changed a great deal, though, by increasing the number of rail cars per train.

Differences in the impacts between regular and dedicated rail service would be primarily due to the differences in apportioning fatalities to rail cars. In actuality, if only three rail cars of TRU waste would be included in both cases, the same number of trains would be needed, and the same number of accidents and fatalities would be expected to occur.

E.7.2 Radiological Impacts of Accident-Free Transportation

As under truck accident-free radiological impact analyses, the impacts to three groups of individuals were assessed: those exposed because they would live along a route, those exposed because they share the transportation corridor, and those exposed during rail stops (inspectors and those at rail stops). The impact to the exposed population would be proportional to the number of

TRUPACT-IIs and RH-72Bs being shipped and the individual package TIs. Because the number of packages to be shipped and the TIs are the same for both truck and rail, these terms were considered to be constants in the impact analyses.

E.7.2.1 Radiation Exposure to Individuals Residing Close to the Transportation Corridor

Using RADTRAN, the overall exposure would be proportional to the TI, the number of packages shipped, the population density, and would be inversely proportional to the speed of the truck or train. The faster the TRU waste passes by a given location, the lower the exposure. The population density can be somewhat different for rail and truck transportation; however, it would be a second order effect, speed being the most important parameter.

For truck transportation analyses, an average highway speed of 55 miles per hour was assumed for all three population areas. For rail, speeds of 40 miles per hour through rural zones, 25 miles per hour through suburban zones, and 15 miles per hour through urban zones were used. Assuming that the total miles would be the same for truck and rail, and the fractions through rural, suburban, and urban zones would be 89, 10, and 1 percent respectively; a 1.5 increase in the impact would occur under rail transportation. A more accurate estimate may be obtained by using the ratios of the total miles in each population zone, multiplied by the inverse ratio of the speeds, and adding these to get the impact increase for rail. The result, in most cases, would be close to 1.5.

E.7.2.2 Radiation Exposure to Individuals Sharing the Transportation Corridor

The number of individuals sharing the transportation route would be very small. At a maximum, the number of individuals sharing the transportation corridor who would be exposed would be two orders of magnitude less than for truck transportation, 0.01 times the highway value.

E.7.2.3 Exposure During Stops

The biggest difference in impacts between truck and rail transportation would be due to exposures during stops. The model for rail analyses assumes that the people in the vicinity of the stopped train are uniformly distributed with a population density equivalent to the suburban density, 719 individuals per square kilometer (1,863 per square mile). In addition, it was assumed that the other freight cars would effectively shield most of the individuals such that the effective exposure would be 1/10th of the exposure without shielding. The effective exposure distance was assumed to range from 10 to 400 meters (33 to 1,312 feet).

The stop duration was calculated for rail using two components, stops en route and stops at classification yards. For regular rail, the stop time en route is equal to 0.033d where "d" is the distance traveled. The time spent in classification yards was assumed to be 32n where "n" is the number of classification yards that must be used to interchange with other railroads. It was assumed that the average time in such a yard would be 32 hours. For dedicated rail, the stop time en route was assumed to equal 0.004d, and the time associated with interchange was 4n. Dedicated rail would, therefore, have exposures approximately eight times smaller than those from regular rail.

The exposure at stops for regular rail would be 1/8 of those for truck transportation. For dedicated rail, exposures would be 1/64 of those for truck.

The basic equation used to model the impact from rail stops is the following:

$$D = TI \times M \times 2\pi \times \ln\left(\frac{400}{10}\right) \times S \times Pop \times T \times \left[1 + N\left(\frac{970}{M}\right)\right] \times 10^{-6} \times 10^{-3} \qquad \text{(Equation E-4)}$$

where

D = Radiation dose in person-rem

TI = Transportation index in mrem per hour

M = Distance traveled in kilometers

S = Radiation shielding factor based on the congestion of rail cars in a rail yard, 0.1

T = Stop time (hours) per kilometer, 0.011

Pop = Population density, 719 persons per square kilometer

N = Number of rail shipment transfers, a minimum of 2 (beginning and end of route)

Therefore, the dose would be:

$$\text{Dose (mrem)} = 1.7\text{ E-4 (TI) (M)} \qquad \text{(Equation E-5)}$$

For dedicated rail shipments, the assumed stop duration was 0.004 hours per kilometer (0.006 per mile), a factor of 8.25 lower than for regular rail shipments. The time at interchanges was a factor of 8 lower for dedicated rail. Thus, dedicated rail service would have a stop time exposure about 8 times lower than for regular rail, and the estimated dose from rail stops would be 64 times lower than the estimated dose from the truck stops.

E.7.3 Impacts from Severe Accidents that Release Hazardous or Radioactive Material

The aggregate radiological consequences of rail transportation accidents were estimated from the aggregate radiological impacts of truck transportation accidents. Because the number of miles traveled were assumed to be similar for truck and rail, and because the frequency of rail accidents would be less than that for truck, the aggregate radiological impacts for rail transportation were assumed to be the same as those reported for truck in Table E-22.

Assuming that there would be three rail cars, with six TRUPACT-IIs per rail car (regular or dedicated), it was estimated that two TRUPACT-IIs could be breached in an impact accident. This bounding-case accident was assumed to be a derailment where two rail cars impact bridge abutments on either side of the tracks. Although other TRUPACT-IIs may experience impact forces, it would not be expected that the forces would be sufficient to breach the container. For the scenarios analyzed, no early fatalities or morbidities were estimated. The estimated population doses were dominated by the inhalation pathway (initial or resuspension). Based upon the failure of two TRUPACT-IIs or RH-72Bs, the impacts from the rail bounding-case accident scenarios for Action Alternatives 1 and 3 would be as follows:

- For the bounding radionuclide inventory in a breached TRUPACT-II, the total population dose was estimated to be 63,600 person-rem, resulting in 32 LCFs in the exposed population. The estimated MEI dose would be 246 rem (TEDE), resulting in a 12 percent chance of a cancer fatality.

- For the bounding radionuclide inventory in a breached RH-72B, the total population dose was estimated to be 65,000 person-rem, resulting in 32 LCFs in the exposure population. The estimated MEI dose would be 250 rem (TEDE), resulting in a 12 percent chance of a cancer fatality.

- For the average radionuclide inventory in a breached TRUPACT-II, a total population dose of 12,740 person-rem was estimated. This would result in approximately 6 LCFs in the exposed population. The estimated MEI dose would be 160 rem (TEDE), resulting in a 8 percent chance of a cancer fatality.

- For the average radionuclide inventory in a breached RH-72B, the total population dose would be 144 person-rem, resulting in an expectation of 0.08 LCF in the population. The estimated MEI dose would be 2.8 rem (TEDE), resulting in a 0.14 percent chance of a cancer fatality.

The impacts due to rail accidents under Action Alternative 2 would be the following:

- For the bounding radionuclide inventory in a breached TRUPACT-II, the total population dose was estimated to be 178 person-rem, resulting in 0.09 LCFs in the exposed population. The estimated MEI dose would be 0.7 rem (TEDE), resulting in a 0.03 percent chance of a cancer fatality.

- For the bounding radionuclide inventory in a breached RH-72B, the total population dose was estimated to be 182 person-rem, resulting in 0.09 LCFs in the exposure population. The estimated MEI dose would be 0.7 rem (TEDE), resulting in a 0.03 percent chance of a cancer fatality.

- For the average radionuclide inventory in a breached TRUPACT-II, a total population dose of 35.6 person-rem was estimated. This would result in approximately 0.02 LCFs in the exposed population. The estimated MEI dose would be 0.5 rem (TEDE), resulting in a 0.02 percent chance of a cancer fatality.

- For the average radionuclide inventory in a breached RH-72B, the total population dose would be 0.4 person-rem, resulting in an expectation of 2×10^{-4} LCFs in the population. The estimated MEI dose would be 0.008 rem (TEDE), resulting in a 4×10^{-4} percent chance of a cancer fatality.

There would be negligible impacts from hazardous chemical releases in a rail transportation severe accident for all alternatives. Because there would be half as many shipments under rail transportation, the aggregate occupational exposure to the train crew would be a factor of two lower. More importantly, the crew of the train would typically be hundreds of feet from the waste. Any exposures would be minimal, and therefore, were not considered. The only radiation exposures occur during train inspections. Very conservatively, the exposure from such activities would be less than 10 percent of the exposure to the crew doing a similar inspection for truck. The train crew would spend its time equally on 70 cars, whereas the truck crew would spend their entire time in close proximity to a radioactive shipping cask. Thus, it can be conservatively estimated that the exposure to the crew of the train would be 0.05 times the occupational exposure to the truck crew.

The impacts from rail (regular and dedicated) transportation are presented in Tables E-29 through E-32. Only the fatal accident projections would be notably different between truck and rail transportation.

E.8 RETRIEVAL AND RECOVERY

The WIPP Land Withdrawal Act states that if the EPA makes a determination of noncompliance during the disposal or decommissioning phase of WIPP, DOE may be required to retrieve (or recover), to the extent practicable, any TRU waste and contaminated material from the WIPP underground disposal facility.

E.8.1 Waste Retrieval

Retrieval consists of the removal of TRU waste from WIPP prior to the time at which the salt creep would begin to crush the waste drums and canisters. The retrieval volumes were assumed to be the same as the emplacement volume of one panel (17,560 cubic meters [620,125 cubic feet]). The waste would be shipped back to the originating generator-storage site. Transportation impacts were based on the number of shipments required to transport a designated volume of TRU waste to WIPP. With no additional waste to transport, the number of shipments required to transport the waste back would be the same as the number required to ship the waste to WIPP. Transportation impacts for retrieval would be identical to the transportation impacts associated with TRU waste emplacement. The impacts for transporting the TRU waste retrieved from one panel at WIPP are presented in Table E-33.

E.8.2 Waste Recovery

Recovery is defined as the removal of TRU waste, waste containers, and any material contaminated by such waste after the time at which the salt creep has crushed some of the containers. As a result, waste would escape into the panels resulting in an additional contamination volume. For the purposes of analyses, it was assumed that recovery would occur following the closure of WIPP and the active institutional control (100-year) period, at which time all containers were assumed to be breached. Analyses were based on the waste volumes of Action Alternative 3 because this alternative has the greatest volume of waste. The total volume of waste would include the amount of contaminated salt from the breached waste drums. This volume was assumed to be 3.4×10^6 cubic meters (1.2×10^6 cubic feet).

It was assumed that, upon removal from WIPP, the waste would be transported to the consolidation sites proposed in the Draft WM PEIS Regionalized 1 Alternative. Each site would receive more waste than its original volume because of the additional volume of contaminated salt. This additional volume of waste would be divided among the sites, commensurate with their original volume. Impacts were based on adjusting the results of the Action Alternative 3 analysis to the waste volume estimates.

The number of shipments would increase by a factor of approximately 8.5, which would result in a factor of 8.5 increase in the transportation impacts. This would be a conservative assumption given that the radionuclides with high gamma activity will have decayed to considerably reduce the accident-free exposures.

Table E-29
Rail (Regular and Dedicated) Transportation Impacts for Action Alternative 1

Aggregate Traffic Related Fatalities	
Regular Rail	9
Dedicated Rail	216
Aggregate Radiological Accident Impacts (LCFs)	
CH-TRU Waste	0.74
RH-TRU Waste	0.084
Total CH-TRU and RH-TRU Waste	0.84
Aggregate Accident-Free Impacts (person-rem)[a]	
CH-TRU Waste	
Occupational	50 (0.02)
Nonoccupational	
Stops	665 (0.3)
Sharing Route	3 (1.6E-3)
Along Route	170 (0.09)
Nonoccupational Total[b]	840 (0.4)
RH-TRU Waste	
Occupational	35 (0.01)
Nonoccupational	
Stops	1.6E+3 (0.8)
Sharing Route	8 (3.8E-3)
Along Route	425 (0.2)
Nonoccupational Total[b]	2.1E+3 (1.0)
Total CH-TRU and RH-TRU Waste	
Occupational	85 (0.03)
Nonoccupational	
Stops	2.3E+3 (1.1)
Sharing Route	11 (5.4E-3)
Along Route	595 (0.3)
Nonoccupational Total[b]	2.9E+3 (1.4)

[a] Number in parentheses equals LCFs.
[b] Total nonoccupational doses include exposure to people at stops, sharing the route, and along the route. Totals may differ from the sums due to rounding.

Table E-30
Rail (Regular and Dedicated) Transportation Impacts for Action Alternative 2

	Action Alternative 2A	Action Alternative 2B	Action Alternative 2C
Aggregate Traffic Related Fatalities			
Regular Rail	4	4	5
Dedicated Rail	97	103	127
Aggregate Radiological Accident Impacts (LCFs)			
CH-TRU Waste	0.4	0.4	0.7
RH-TRU Waste	0.03	0.03	0.03
Total CH-TRU and RH-TRU Waste	0.4	0.4	0.7
Aggregate Accident-Free Impacts (person-rem)[a]			
CH-TRU Waste			
Occupational	30 (0.01)	35 (0.01)	50 (0.02)
Nonoccupational			
Stops	410 (0.2)	460 (0.2)	670 (0.3)
Sharing Route	2 (1.0E-3)	2 (1.0E-3)	3 (1.5E-3)
Along Route	110 (0.06)	120 (0.06)	175 (0.09)
Nonoccupational Total[b]	520 (0.3)	585 (0.3)	845 (0.4)
RH-TRU Waste			
Occupational	15 (6.0E-3)	15 (6.0E-3)	15 (6.0E-3)
Nonoccupational			
Stops	590 (0.3)	590 (0.3)	590 (0.3)
Sharing Route	3 (1.5E-3)	3 (1.5E-3)	3 (1.5E-3)
Along Route	150 (0.08)	150 (0.08)	150 (0.08)
Nonoccupational Total[b]	745 (0.4)	745 (0.4)	745 (0.4)
Total CH-TRU and RH-TRU Waste			
Occupational	45 (0.02)	50 (0.02)	65 (0.03)
Nonoccupational			
Stops	1.0E+3 (0.5)	1.1E+3 (0.5)	1.3E+3 (0.6)
Sharing Route	5 (2.5E-3)	5 (2.5E-3)	6 (3.0E-3)
Along Route	260 (0.1)	270 (0.1)	325 (0.2)
Nonoccupational Total[b]	1.3E+3 (0.7)	1.3E+3 (0.7)	1.6E+3 (0.8)

[a] Number in parentheses equals LCFs.
[b] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route. Totals may differ due to rounding.

Table E-31
Rail (Regular and Dedicated) Transportation Impacts for Action Alternative 3

Aggregate Traffic Related Fatalities	
Commercial Rail	13
Dedicated Rail	303
Aggregate Radiological Accident Impacts (LCFs)	
CH-TRU Waste	1.1
RH-TRU Waste	0.1
Total CH-TRU and RH-TRU Waste	1.2
Aggregate Accident-Free Impacts (person—rem)[a]	
CH-TRU Waste	
Occupational	85 (0.03)
Nonoccupational	
Stops	1.1E+3 (0.6)
Sharing Route	5 (2.5E-3)
Along Route	280 (0.1)
Nonoccupational Total[b]	1.4E+3 (0.7)
RH-TRU Waste	
Occupational	40 (0.02)
Nonoccupational	
Stops	1.9E+3 (1.0)
Sharing Route	9.0 (4.5E-3)
Along Route	480 (0.2)
Nonoccupational Total[b]	2.4E+3 (1.2)
Total CH-TRU and RH-TRU Waste	
Occupational	125 (0.05)
Nonoccupational	
Stops	3.0E+3 (1.6)
Sharing Route	15 (7.0E-3)
Along Route	740 (0.3)
Nonoccupational Total	3.8E+3 (1.9)

[a] Number in parentheses equals LCFs.
[b] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route. Totals may differ due to rounding.

Table E-32
Rail (Regular and Dedicated) Transportation Impacts for No Action Alternative 1

	No Action Alternative 1A	No Action Alternative 1B
Aggregate Traffic Related Fatalities		
Regular Rail	0.09	0.6
Dedicated Rail	2	16
Aggregate Radiological Accident Impacts (LCFs)		
CH-TRU Waste	5.6E-3	0.02
RH-TRU Waste	1.2E-3	1.2E-3
Total CH-TRU and RH-TRU Waste	6.8E-3	0.02
Aggregate Accident-Free Impacts (person—rem)[a]		
Total CH-TRU and RH-TRU Waste		
Occupational	0.6 (3.2E-4)	8 (3.2E-3)
Nonoccupational		
Stops	20 (0.01)	115 (0.06)
Sharing Route	0.1 (5.0E-5)	0.6 (3.0E-4)
Along Route	6 (3.0E-3)	35 (0.02)
Nonoccupational Total[b]	30 (0.02)	150 (0.08)

[a] Number in parentheses equals LCFs.
[b] Total nonoccupational exposure is the sum of exposures to persons at stops, sharing the route, and along the route. Totals may differ due to rounding.

Table E-33
Waste Retrieval Impacts

Nonradiological Impacts	
Vehicle Emission-related Fatalities	9.8E-3
Vehicle Related Fatalities	0.5
Accident-Free Radiological Impacts	
Occupational (person-rem)	68
Nonoccupational (person-rem)	520
Occupational (LCFs)	0.03
Nonoccupational (LCFs)	0.3

Given the half-lives of the radionuclides which contribute most to internal doses (alpha emitters), it was conservatively assumed that the maximum bounding accident exposures would be the same. Because, the mode of transportation would be the same, and the accident statistics would remain relatively constant, the number of accidents, injuries, fatalities, and LCFs from pollution effects would also increase by a factor of approximately 8.5. As in the original shipment of the waste, the transportation impact will be dominated by nonradiological impacts. Table E-34 presents a summary of the estimated transportation impacts associated with transporting TRU waste recovered from WIPP.

Table E-34
Waste Recovery Impacts

Nonradiological Impacts	
Vehicle Emission-related Fatalities	6
Vehicle Related Fatalities	213
Accident-Free Radiological Impacts	
Occupational (person-rem)	2.5E+3
Nonoccupational (person-rem)	2.8E+4
Occupational (LCFs)	1
Nonoccupational (LCFs)	14

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APPENDIX F

APPENDIX F
HUMAN HEALTH

This appendix describes the methods used to estimate human health impacts that may result from exposure to radioactive material and hazardous chemicals during routine storage operations at waste storage sites and during routine disposal operations at the Waste Isolation Pilot Plant (WIPP). During routine operations, members of the public and workers may be exposed to small quantities of hazardous volatile organic compounds (VOC) and radioactive gases released from vented waste containers. Routine releases of particulates are not expected because container vents have filters to prevent such a release. VOCs and gaseous radionuclides may be released to the environment from exhaust ventilation system emissions at the WIPP Waste Handling Building (WHB) and the underground area. At waste storage sites, there may be releases to the environment from the ventilation exhaust of the facilities, therefore, environmental releases would be the source of potential impacts for the population within 80 kilometers (50 miles) of the facilities, the maximally exposed individual (MEI), the noninvolved worker population (employees not directly involved in waste storage or disposal operations), and the maximally exposed noninvolved worker. Involved workers, those directly involved with waste storage and disposal operations, may also be exposed to direct radiation from radioactive material in the containers as well as the waste container emissions. Human health impacts were calculated for all of these potential receptors from storage and waste disposal activities. Waste treatment impacts were based upon information presented in the *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS). Information on the adjustment of the Draft WM PEIS results is presented in Appendix B.

Based on new information and revised assumptions, these analyses update the impacts reported in the 1990 *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990). The total transuranic (TRU) waste inventory, individual waste container inventories, and different types of treatment for the waste are among the more notable updates.

F.1 TECHNICAL APPROACH

To estimate human health impacts from exposure to radioactive material and VOCs, spreadsheet calculations and three computer codes were used. Spreadsheets were used to estimate the radiological impacts from routine releases of radioactive gases. The GENII computer code was used to calculate the atmospheric dispersion factors for radioactive gas emissions at waste storage sites and WIPP for input into the spreadsheets (Napier et al. 1988). Version 1.95 of the ISO-PC computer code was used to estimate external radiation doses to involved workers (Rittman 1995). The MEPAS® code was used to estimate hazardous chemical carcinogenic and noncarcinogenic (toxicological) impacts to the public and noninvolved workers from releases of VOCs (Droppo et al. 1989; Strenge and Peterson 1989; Buck et al. 1995; Strenge and Chamberlain 1995; Droppo and Buck 1996). None of these three computer codes could be used to estimate the near-field impacts to involved workers from routine releases of radioactive gases and hazardous chemicals from TRU-waste containers. Therefore, for impacts to involved workers, computer spreadsheets were used to estimate impacts from routine operations.

F.1.1 Radiological Impacts

Computer spreadsheets were used to estimate the radiological impacts to the population, MEI, noninvolved workers, and involved workers from routine releases of radioactive gases. The

radionuclide inventories detailed in Appendix A include the radioactive gases radon-222, radon-220, and carbon-14. These gases may slowly escape through the composite carbon filter, which is on each waste container. No routine release of particulate radioactive material would occur at storage sites or at WIPP during routine operations because of the filters. GENII was used to calculate the average annual atmospheric dispersion factors that were used to estimate far-field radiation doses to the population, MEI, and noninvolved workers from the release of radioactive gases. Atmospheric dispersion was calculated by GENII using a straight-line Gaussian-plume model with site-specific meteorologic data. Because the GENII atmospheric dispersion model is not valid for the near-field scenario, computer spreadsheets were used to estimate the near-field radiological impacts to involved workers from releases of radioactive gases from waste containers.

The major contributor to potential radiological impacts for involved workers is external radiation emitted from the radionuclides present in TRU waste. The ISO-PC code was used to estimate the average surface and 1-meter (3.3-foot) dose rates of the TRU waste drums. The surface and 1-meter (3.3-foot) dose rates of the contact-handled (CH) TRU waste drums were used to estimate the radiological impacts to involved workers from waste handling, storage, disposal, and management activities.

The ISO-PC code, which is based on the ISOSHLD-II code, calculates dose rates from radioactive sources using user-defined geometries. Container dose rates vary with radionuclide concentration and waste density. For a given radionuclide concentration, a more dense waste would have more self-shielding and, thereby, would have a lower external dose rate. For this *Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II), the density of waste is closely tied to the level of waste treatment.

Average dose rates were calculated using the geometry and wall-thickness of the TRU waste containers, the alternative- and consolidation-site-specific average TRU waste density, and the site-specific average TRU waste radionuclide concentrations. The CH-TRU waste drum was modeled as being 82 centimeters (32 inches) high and 56 centimeters (22 inches) in diameter with an iron wall 0.16 centimeters (0.06 inches) thick. It was assumed, for all alternatives, that the radionuclides and waste were uniformly dispersed within the drum. The radionuclide inventories in Appendix A were used.

Radiological impacts were calculated as the total effective dose equivalent (TEDE), which is the sum of the external effective dose equivalent and the 50-year committed effective dose equivalent from radionuclides taken into the body. The TEDE was converted into the risk of a latent cancer fatality (LCF) using dose-to-risk factors published in *Recommendations of the International Commission on Radiological Protection,* ICRP Publication 60 (ICRP 60) (ICRP 1991), which presents risk estimates based on data from populations that received relatively high radiation doses at high dose rates. When the dose to an individual is below 20 rads per year, as is typically the case with doses resulting from radioactive gas releases, a reduction factor of two is used. The dose-to-risk conversion factors used for estimating cancer deaths from radiation exposures less than 20 rads per year are: (1) 500 LCFs per million person-rem effective dose equivalent or 5.0×10^{-4} LCFs per person-rem for the general population; and (2) 400 LCFs per million person-rem or 4.0×10^{-4} LCFs per person-rem for workers. The difference between the two conversion factors is attributable to an increased sensitivity to radiation among the very young and very old within the general population. Potential radiological impacts to populations (public, noninvolved worker, and involved worker) are reported as the expected number of LCFs that may occur. Radiological impacts to the MEI and the maximally exposed noninvolved worker are

reported as the percent chance (or probability) of an LCF occurring. No estimate of the impact to the maximally exposed involved worker was made because of the high degree of variability.

The ICRP 60 risk factors used in SEIS-II are approximately twice those values in SEIS-I, which used *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980* (BEIR-III) risk factors that were current at the time (BEIR 1980). ICRP 60 risk factors are higher due to an improved reconstruction of the exposures on which the dose-to-risk factors were based and information obtained during an extended population follow-up time. By including the incidence of nonfatal cancers and severe hereditary effects from radiation exposure, a total detriment 1.4 to 1.5 times greater than the LCF risk estimate would result (ICRP 1991). These were not included in SEIS-II.

F.1.2 Hazardous Chemical Impacts

Hazardous chemical impacts may result from the routine release of VOCs from waste containers at waste storage sites and at WIPP. No routine releases of particulate hazardous chemicals (metals) would occur at storage sites or at WIPP because the waste containers are filtered. Atmospheric dispersion was estimated by MEPAS® using a straight-line Gaussian-plume model and site-specific meteorological data. MEPAS® cannot be used for the near-field exposure scenarios of involved workers, so computer spreadsheets were used to estimate potential hazardous chemical impacts.

Impacts from exposure to carcinogenic VOCs are presented as the risk of cancer incidence. The U.S. Environmental Protection Agency (EPA) has published slope factors that are based on chronic exposures to specific hazardous chemicals (EPA 1996). Slope factors are used to estimate the mathematical expectation that an individual will contract cancer in his/her lifetime from chronic exposure to a specific hazardous chemical. Estimates of carcinogenic risk to a population indicate the number of cancers expected within a population as a result of a chronic hazardous chemical exposure. Slope factors for the VOCs evaluated in SEIS-II are found in Table F-1.

Noncarcinogenic health effects from chronic exposure to routine releases of VOCs are presented as a Hazard Index (HI). Noncarcinogenic health effects are nonprobabilistic and have an occurrence threshold. The HI is equal to the individual's estimated exposure divided by the EPA chemical-specific "reference dose" (EPA 1996). The EPA reference dose is based on the exposure level at which a deleterious effect is noted following chronic exposure over a year. Table F-2 presents the reference doses used in SEIS-II analyses and the effect upon which each is based.

Toxicological effects are not expected if the estimated HI is less than one. In some cases, initial conservative screening estimates of involved worker exposures resulted in HI values greater than one. In these cases, the estimated air concentrations to which the worker was exposed was compared to the Occupational Safety and Health Administration (OSHA) Permissible Exposure Level (PEL) for that VOC (NIOSH 1996) (see Table F-3). Unless otherwise noted, PELs are time-weighted averages that must not be exceeded during any 8-hour shift of a 40-hour workweek. Methylene chloride and chloroform have PEL ceiling values that must not be exceeded over any period of time. Because a PEL does not exist for 1,1-dichloroethylene, air concentrations for this VOC were compared to the American Conference of Governmental Industrial Hygienists (ACGIH) Short-Term Exposure Level (STEL) (NIOSH 1996). Overall, the general public is more sensitive to hazardous chemicals than are workers; therefore, an HI of greater than one for a worker signifies the need for further evaluation and perhaps mitigation rather than the expectation of the noncarcinogenic impact.

Table F-1
Carcinogenic Risk Factors for VOCs

VOC	Slope Factor [risk per (milligram per kilogram per day)][a]	Comment
Carbon tetrachloride	Inhalation = 0.053 Ingestion = 0.13	Probable human carcinogen.
Chlorobenzene	Inhalation = not available Ingestion = not available	Classification as a carcinogen is not possible due to poor database of carcinogenic effects upon which to base a determination.
Chloroform	Inhalation =0.081 Ingestion = 6.1E-3	Probable human carcinogen.
Methyl Ethyl Ketone	Inhalation = 0.0 Ingestion = 0.0	Not carcinogenic.
Methylene Chloride	Inhalation = 1.6E-3 Ingestion = 7.5E-3	Probable human carcinogen.
1,1,2,2-Tetrachloroethane	Inhalation = 0.2 Ingestion = 0.2	Possible human carcinogen.
Toluene	Inhalation = not available Ingestion = not available	Classification as a carcinogen is not possible due to the poor database of carcinogenic effects upon which to base such a determination.
1,1-Dichloroethylene	Inhalation = 0.18 Ingestion = 0.6	Possible human carcinogen.
1,2-Dichloroethane	Inhalation = 0.091 Ingestion = 0.091	Probable human carcinogen.
Benzene	Inhalation = 0.029 Ingestion = 0.029	Human carcinogen (leukemia).
Xylene	Inhalation = 0 Ingestion = 0	Carcinogenicity is under review.
Tetrachloroethene	Inhalation = not available Ingestion = not available	Carcinogenicity is under review. SEIS-II assumes an inhalation slope factor of 1.8E-3 and an ingestion slope factor of 0.051, as cited in Strenge and Peterson (1989).
Ethyl Benzene	Inhalation = not available Ingestion = not available	Classification as a carcinogen is not possible due to the poor database of carcinogenic effects upon which to base such a determination.

[a] The inhalation slope factor from IRIS was converted to risk per milligram per kilogram per day by assuming an inhalation rate of 20 cubic meters per day and an individual body mass of 70 kilograms (EPA 1996).

Because the noncarcinogenic health impacts are nonprobabilistic, the results of calculations for the MEI represent the bounding indicator of noncarcinogenic risks to the 80-kilometer (50-mile) population.

F.2 ANALYSIS METHODS AND ASSUMPTIONS

This section describes the background data used in the routine exposure impact analyses. This information is separated into three general categories: radionuclide and VOC source terms, atmospheric transport, and exposure scenarios. Radionuclides and VOCs would be routinely released only to the atmosphere. There is no surface water or groundwater near WIPP, no water is used in the disposal process, and no mechanisms exist for direct soil contamination. Atmospheric transport modeling was used to determine the locations where maximum exposures could occur. Individuals were assumed to be present at these locations, providing a bounding exposure estimate for any individual in the region. Exposure scenarios include assumptions for both individuals and

Table F-2
Noncarcinogenic Health Effect Measures for VOCs

VOC	Reference Dose (RfD) (milligrams per kilogram per day)[a]	Comment/Assumption
Carbon tetrachloride	Inhalation, not available Ingestion = 7E-4	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, based on liver lesions.
Chlorobenzene	Inhalation, under review Ingestion = 0.02	Medium confidence level for ingestion RfD, based on histopathologic changes in the liver. Assumption: Inhalation RfD = 5.7E-3, from EPA HEAST values (Strenge and Petersen 1989).
Chloroform	Inhalation, under review Ingestion = 0.01	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, based on fatty cyst formation in the liver.
Methyl ethyl ketone	Inhalation = 0.29 Ingestion = 0.61	Low confidence level for both inhalation and ingestion RfDs, based on decreased fetal birth weight.
Methylene chloride	Inhalation, under review Ingestion = 0.06	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, based on liver toxicity.
1,1,2,2-tetrachloroethane	Inhalation, not available Ingestion, not available	No details available. Assumption: RfDs are zero.
Toluene	Inhalation = 0.11 Ingestion = 0.2	Medium confidence level for inhalation and ingestion RfDs. Inhalation RfD based on neurological effects. Ingestion RfD based on changes in liver and kidney weight.
1,1-dichloroethylene	Inhalation, under review Ingestion = 9E-3	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, is based on the growth of hepatic lesions.
1,2-dichloroethane	Inhalation, not available Ingestion, not available	No details available. Assumption: RfDs are zero.
Benzene	Inhalation, not available Ingestion, not available	No details available. Assumption: RfDs are zero.
Xylene	Inhalation, under review Ingestion = 2.0	Assumption: Inhalation RfD = 0.086 based on previous EPA data (Strenge and Peterson 1989). Medium confidence level for ingestion RfD, based on hyperactivity, decreased body weight, and increased mortality (males only).
Tetrachloroethene	Inhalation, not available Ingestion = 0.01	Assumption: Inhalation RfD is equivalent to ingestion RfD. Medium confidence level for ingestion RfD, based on hepatotoxicity and weight gain.
Ethyl benzene	Inhalation = 0.29 Ingestion = 0.1	Low confidence levels for inhalation and ingestion RfDs. Inhalation RfD based on developmental toxicity. Ingestion RfD based on liver and kidney toxicity.

[a] Inhalation reference concentrations listed in IRIS are converted to RfDs by assuming an inhalation rate of 20 cubic meters per day and an individual body mass of 70 kilograms (EPA 1996).

Table F-3
Involved Worker Supplemental Noncarcinogenic Health Effect Measures for VOCs

VOC	Permissible Exposure Level (PEL)[a]
Carbon Tetrachloride	2 parts per million
Chlorobenzene	75 parts per million
Chloroform	Not to exceed 2 parts per million
1,1-Dichloroethylene	None[b]
1,2-Dichloroethane	50 parts per million
Methyl Ethyl Ketone	200 parts per million
Methylene Chloride	500 parts per million[c]
1,1,2,2-Tetrachloroethane	5 parts per million
Toluene	100 parts per million[d]

[a] Time-weighted concentration over an 8-hour exposure period unless otherwise noted.
[b] ACGIH recommends a 5 ppm over an 8-hour limit, with a short-term exposure limit (STEL) of 20 ppm.
[c] Maximum 5-minute concentration of 2000 ppm, not to be exceeded.
[d] Maximum 15-minute concentration of 150 ppm for any 2-hour period.

populations for the primary exposure pathways of inhalation, dermal absorption, and external exposure and for the secondary exposure pathways of contaminated food and incidental soil ingestion. Radionuclide inventories detailed in Appendix A were used. Likewise, VOC source terms were developed as described in Appendix A. To conservatively estimate the impacts to the WHB worker, VOC inventories based on the WIPP planning-basis Waste Acceptance Criteria (WAC) (DOE 1996b) limits were used.

F.2.1 Source Terms

Impacts from routine releases of gaseous radionuclides and VOCs were estimated for the Total Inventory of TRU waste. The impacts were then assigned to either the Basic Inventory or the Additional Inventory based on the fractional volume of each. The radionuclide and VOC content of the Additional Inventory is unknown; therefore, the radionuclide and VOC headspace concentrations of the Basic Inventory were used for the Additional and Total Inventories.

F.2.1.1 Radionuclide Source Term

The impact estimates from routine operations evaluated in SEIS-I have been refined in SEIS-II. Detailed radionuclide inventory information (Appendix A) was taken from the *Transuranic Baseline Inventory Report* (BIR-2), whereas SEIS-I inventories were limited to those pertaining to plutonium-239 equivalent curies (PE-Ci). Routine radiological impacts would result from the release of gaseous radionuclides through the composite filters of the waste containers and, for involved workers only, external radiation doses from waste handling operations. Releases of gaseous radionuclides are discussed below; additional information on radionuclides contributing to involved worker external dose is presented in Section F.2.3.

Radiological impacts from releases of gaseous radionuclides were estimated for the major consolidation sites. Conservative impacts at WIPP were calculated for all alternatives except Action Alternative 2C, for which no impacts were calculated because radionuclide inventories at the consolidation sites are included in WIPP estimates and no credit was taken for panel closures. Radionuclides included in the analyses were radon-222 and carbon-14. While radon-220 is listed in some of the site radionuclide inventories, it has a halflife of only 56 seconds. Very little of the gas, if any, would escape the waste container before it radioactively decays to polonium-216, a radionuclide that would be trapped as a particulate within the waste or the container filter. Small quantities of other gaseous radionuclides may also be present in TRU waste, but they would be negligible contributors to either worker or population doses.

For carbon-14, the entire WIPP or consolidation site radionuclide inventory was assumed to be released as an organic carbon (e.g., methane). Organic carbon-14 forms have a dose factor two and three orders of magnitude greater than the dose factors of carbon-14 in the form of carbon dioxide or carbon monoxide, respectively (DOE 1988b). Therefore, by assuming this chemical form, the radiological impact estimate was maximized.

Radon-222 is continuously generated in the waste from the decay of radium-226, which has a halflife of 1,600 years. For every curie (Ci) of radium-226 in the waste inventory, 2.1×10^{-6} Ci of radon-222 are produced each second. Only radon-222 is released from the waste containers, however, because particulate radon progeny are trapped by the composite filters on each container. Therefore, the ICRP 65 dose factor (ICRP 1993) for radon-222 alone, 273.8 rem-cubic meter per Ci-hour was used to determine the radiological impacts. For waste treated to meet WAC, all of the

radon-222 that would be generated over a lifetime exposure period (70 years for the MEI, 35 years for workers and populations) in the waste inventory at WIPP or the consolidation sites was assumed to escape the waste container. For waste treated to meet the WIPP Land Disposal Restrictions (LDR), only a small fraction of the radon would be able to escape the monolithic mass before it decays. It was assumed, therefore, that 25 percent of the radon generated over the lifetime exposure period was released from the container. Waste treated by shred and grout would be more porous than LDR waste and less porous than WAC waste. In this case, 50 percent of the radon-222 generated over the lifetime exposure period was assumed to escape the waste container. The estimated release fractions account for the amount of gas captured within the waste and not readily escaping the container.

F.2.1.2 VOC Source Term

VOCs may be released routinely from the TRU waste containers through the composite filters because the purpose of the filter is to prevent gas build-up within the container. However, no hazardous metal particulates would be released through the filter. The release rate of the VOCs would be linearly related to the headspace concentration in the waste container. Routine exposures were assessed using average waste contents because exposures may vary over short-term periods but will average out over the long-term periods evaluated in SEIS-II.

No quantitative information on the hazardous chemical inventory of TRU waste is available. Headspace sampling data on 31 VOCs in 900 CH-TRU waste containers are provided in the Resource Conservation and Recovery Act (RCRA) Part B Permit Application (DOE 1996a, Table C8-2). This list of VOCs incorporates sampling data from TRU waste containers at Idaho National Engineering Laboratory (INEL) and Rocky Flats Environmental Technology Site (RFETS) whereas only RFETS data was available for SEIS-I. Information on both the average and the maximum waste container inventories is available for a number of VOCs present in TRU waste.

Headspace concentrations of each VOC vary according to the waste matrix. No VOCs would be present in waste after treatment under Action Alternative 2 or No Action Alternative 1 because the thermal treatment destroys VOCs in the waste. Waste treated to meet WAC under the Proposed Action, Action Alternative 1, and the No Action Alternative 2 would contain a variety of waste matrices. A weighted average headspace concentration for waste at WIPP and each of the major waste consolidation sites was calculated for each alternative (see Appendix A). The matrix composition varies by consolidation site, so weighted average headspace concentrations for each consolidation site under Action Alternative 1 and No Action Alternative 2 were determined. The matrix composition under Action Alternative 3 would be a uniform solidified inorganic matrix, so the headspace concentrations of all Action Alternative 3 consolidation sites were assumed to be the same. Headspace concentrations of waste disposed of at WIPP are shown in Table F-4. The average and weighted average concentrations were used for routine release evaluations except for impacts to WIPP involved workers in the WHB, where higher concentrations were used.

Container VOC release rates were based on the diffusion rate of the VOC through the composite filter (DOE 1995a). Release rates are VOC-specific and are proportional to the headspace concentration. Filter diffusion rates and VOC release rates for a single CH-TRU drum are shown in Table F-5. Impacts for routine releases were determined using this information.

Table F-4
TRU Waste VOC Headspace Concentrations Used in Health Impact Analyses for WIPP

VOC (milligrams per cubic meter per ppmv)	Planning-Basis WAC Headspace Limit (ppmv)[a]	Treated to Meet Planning-Basis WAC (ppmv)		Treated by Shred and Grout (ppmv)	
		Weighted Average	Maximum[b]	Weighted Average	Maximum[c]
Carbon tetrachloride (6.39)	7,510	184.5	---	316.5	---
Chloroform (4.96)	6,325	13.7	---	1.2	---
1,1-dichloroethylene (4.03)	500[d]	8.4	---	2.5	---
1,2-dichloroethane (4.11)	9,100	5.6	---	1.1	---
Methylene chloride (3.53)	368,500	662.1	---	8.1	---
Chlorobenzene (4.68)	No Limit	8.4	956.4 4,368	1.3	260
Methyl ethyl ketone (3.0)	No Limit	40.4	2,946 39,311	6.8	130
1,1,2,2-tetrachloroethane (7.0)	No Limit	335.7	537.6 4,368	125.1	270
Toluene (3.83)	No Limit	5.7	764.8 6,992	1.3	320
Benzene (3.25)	500[d]	7.6	---	22.4	---
Ethyl benzene (4.41)	500[d]	8.5	---	31.6	---
Tetrachloroethene (6.89)	No Limit	7.1	229.7 2184	21.6	600
Xylene (4.41)	500[d]	25.6	---	113.9	---

[a] DOE 1996b.
[b] Used for those VOCs without a maximum planning-basis WAC limit. Top values are weighted maximums determined by weighting by the maximum headspace concentration of each matrix and were used in routine WHB worker bounding scenarios. Bottom values are maximum concentrations found in any solidified organic sampled and were used for the bounding accident scenarios.
[c] Maximum concentration found in any solidified inorganic matrix for those VOCs without a planning-basis WAC limit.
[d] Flammable VOC limit.

Table F-5
Average Single Drum Release Rate of Headspace VOCs (grams per second)

VOC	Filter Diffusion Rates (mol/s/molfrac)[a]	Action Alternative 3	Proposed Action, Action Alternative 1, and No Action Alternative 2						
		All sites	Hanford	INEL	LANL	RFETS	ORNL	SRS	WIPP Under-ground
Carbon tetrachloride	1.21E-6	5.9E-8	1.1E-8	6.9E-8	5.1E-8	5.1E-8	1.7E-8	2.3E-8	3.4E-8
Chlorobenzene	1.16E-6	1.7E-10	1.3E-9	1.2E-9	8.1E-10	3.5E-10	1.2E-9	1.1E-9	1.1E-9
Chloroform	1.34E-6	1.8E-10	1.9E-9	2.8E-9	2.2E-9	1.4E-9	3.0E-9	2.6E-9	2.2E-9
Methyl ethyl ketone	1.30E-6	6.4E-10	3.8E-9	5.1E-9	2.0E-9	1.8E-9	5.8E-9	5.0E-9	3.8E-9
Methylene chloride	1.48E-6	1.0E-9	1.2E-7	6.0E-8	9.5E-8	1.2E-8	1.8E-8	2.0E-8	8.3E-8
1,1,2,2- tetrachloroethane	1.21E-6	2.5E-8	6.3E-8	9.2E-8	2.6E-8	2.9E-8	1.4E-7	1.3E-7	6.8E-8
Toluene	1.20E-6	1.4E-10	6.7E-10	7.8E-10	4.2E-10	2.5E-10	8.4E-10	7.4E-10	6.3E-10
1,1-dichloroethene	1.40E-6	3.3E-10	1.2E-9	1.4E-9	6.1E-10	4.4E-10	1.9E-9	1.7E-9	1.1E-9
1,2-dichloroethane	1.40E-6	1.5E-10	8.3E-10	9.6E-10	5.0E-10	3.0E-10	1.1E-9	9.2E-10	7.8E-10
Benzene	1.32E-6	2.3E-9	6.0E-10	8.7E-10	1.3E-9	8.5E-10	3.0E-10	6.2E-10	7.9E-10
Ethyl benzene	1.10E-6	3.7E-9	6.8E-10	1.1E-9	1.9E-9	1.1E-9	1.9E-10	7.3E-10	9.9E-10
Tetrachloroethene	1.13E-6	4.1E-9	1.0E-9	1.5E-9	2.3E-9	1.5E-9	3.9E-10	9.6E-10	1.3E-9
Xylene (mixed)	1.11E-6	1.3E-8	1.7E-9	3.6E-9	6.3E-9	3.7E-9	4.0E-10	2.4E-9	3.0E-9

[a] Filter diffusion rates for most constituents are from Table D9-3 (DOE 1996a). For methyl ethyl ketone, benzene, ethyl benzene, tetrachloroethene, and xylene, the values were calculated from Equation D9-1 and D9-2 (DOE 1996a) assuming the respective $P_{c,\,VOC}$: 41.52, 48.34, 35.53, 44.57, 36.81; respective $T_{c,\,VOC}$: 536.8, 562.2, 617.2, 620.2, 616.2; and respective molecular weights: 72.1, 78.1, 106.2, 165.8, 106.2.

Routine hazardous chemical impacts at WIPP would be dependent on the release of VOCs from TRU waste containers in the WHB and the underground area for the Proposed Action, Action Alternative 1, and Action Alternative 3. Containers in the WHB were assumed to have VOC headspace concentrations at the planning-basis WAC limit. For VOCs without planning-basis WAC concentration limits, the weighted maximum headspace concentration was used. These concentrations were determined by weighting the *maximum* matrix-specific headspace concentrations rather than the *average* matrix-specific headspace concentrations (see Appendix A). The resulting impact estimates bound any impacts for workers in the WHB. Containers in the underground area were assumed to have the average weighted VOC headspace concentrations shown in Table F-4. No remote-handled (RH) TRU waste VOC headspace concentration data are available, so concentrations were assumed to be identical to those in CH-TRU waste.

A limited number of CH-TRU drums (42) and RH-TRU containers (3) can be present in the WHB at any one time. In contrast, the WIPP underground disposal area would have a much larger number of containers at any one time. A maximum of approximately 80,000 CH-TRU drum-equivalents and approximately 1,200 RH-TRU canisters could be placed in a panel. The number of CH-TRU and RH-TRU drum-equivalents are shown in Table F-6. Total VOC releases from the underground area were calculated using the average single drum release rates in Table F-5 and multiplying them by the number of VOC releasing drum-equivalents in Table F-6.

Table F-6
Number of Drum-Equivalents Assumed for the Evaluation of Routine VOC Releases

	Proposed Action		Action Alternative 1		Action Alternative 3		No Action Alternative 2	
Site	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste
WIPP[a]	80,814	3,620	80,815	3,621	81,170	4,345	N/A	N/A
Hanford-East[b]	N/A	N/A	288,683	73,208	699,731	191,548	138,199	49,593
Hanford-West[b]	N/A	N/A	288,603	73,208	699,731	191,548	138,199	49,593
INEL	N/A	N/A	417,280	11,538	503,101	0	135,314	744
LANL	N/A	N/A	169,320	1,668	201,524	0	101,109	770
RFETS	N/A	N/A	82,695	0	89,869	0	52,221	0
ORNL	N/A	N/A	10,143	26,852	0	32,220	8,027	1,036
SRS	N/A	N/A	81,433	0	112,929	0	58,003	0

[a] Drum-equivalents in a single panel.
[b] Hanford's waste volume was equally distributed between the Hanford-East and Hanford-West locations.

N/A = Not Applicable

The number of drum-equivalents of CH-TRU waste in the underground area were calculated by dividing the total volume of waste to be emplaced by 0.208 cubic meters (7 cubic feet), which is the volume of a single drum. The number of drum-equivalents of RH-TRU waste in the underground area were calculated by dividing the total RH-TRU waste volume by the waste volume of an RH-TRU canister, 0.89 cubic meters (31 cubic feet) and then multiplying by three, the number of individual drums in an RH-TRU canister. Releases from RH-TRU canisters were modeled as from the three drums contained in a canister.

A full panel of drum-equivalent containers was assumed to continuously emit VOCs, which would be released by the underground ventilation system throughout each year of operations. Approximately 80,000 drum-equivalents were assumed for the CH-TRU source term. More likely,

assuming that approximately two years would be required to fill a typical panel, there would be an average of 20,000 CH-TRU drums emitting VOCs over the first year and an average of 60,000 drums emitting VOCs over the second year. Release from RH-TRU waste does not consider any reduction from the canister containment or from use of the RH-TRU shielding plug.

Conservative VOC release estimates were also made for the waste consolidation sites. The VOCs were assumed to be released at the same rate over a lifetime exposure period, which does not consider the offsite transport of the waste from any site to WIPP for disposal.

F.2.2 Atmospheric Transport

The GENII and MEPAS® codes were used to estimate the atmospheric dispersion and transport of radionuclides and hazardous chemicals, respectively. Atmospheric transport was modeled using site-specific meteorologic data. Routine release impact analyses used annual average meteorologic data for the MEI, the maximally exposed noninvolved worker, and the noninvolved worker population and sector-averaged air concentrations (i.e., averaged across sixteen 22.5-degree sectors) for the population within 80 kilometers (50 miles) of WIPP or the storage facility.

The meteorologic data used in MEPAS® and GENII are joint frequencies of wind speed, wind direction, and atmospheric stability class. Average, multi-year data are most appropriate to use when modeling future releases because the site-specific probability of occurrence of dispersion values for any particular location in the region is recognized. Meteorologic data sets used for the major consolidation sites were the same as those used in the Draft WM PEIS (DOE 1995c). The meteorologic joint frequency data file for WIPP is shown in Table F-7. Meteorologic data have been recorded at the WIPP site for several years, but the data recording system has captured the data only about half of the time. These data do not adequately characterize the site-specific conditions, therefore, more complete data from the airport in Carlsbad, New Mexico, were used (NOAA 1995).

Meteorologic data were used with effluent release information to determine the dispersion characteristics of WIPP releases. Releases from WIPP to the environment could occur from the stacks at either the WHB or the Exhaust Filter Building, the latter handling the underground ventilation. For each stack release, a stack height and diameter, release velocity, and effluent temperature (Table F-8) was characterized in MEPAS® and GENII. The dispersion estimates used for individual and population impacts were slightly more conservative (i.e., less dispersion of the release) using the Exhaust Filter Building release parameters. Therefore, the Exhaust Filter Building release parameters were used to conservatively model both the WHB and the underground releases at WIPP. Effluent stack releases were assumed to have a 10-meter (33-foot) effective release height at all treatment/consolidation sites.

Routine releases of hazardous chemicals would occur at the consolidation sites during the lag storage period. Therefore, impacts were estimated for the major consolidation sites under all action alternatives. The locations of the MEI and noninvolved worker were determined based on dispersion estimates. Lag storage facilities under the action alternatives were assumed to be at the same locations as the No Action Alternative 2 storage facilities. The locations of the MEI and the maximally exposed noninvolved worker at the major consolidation sites are shown in Table F-9.

Table F-7
Meteorologic Joint Frequency Data Used for WIPP Atmospheric Releases (Percent of Time)

Ave. Wind Speed (m/s)	Atmos-pheric Stability Class	Direction (Wind Toward)															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
1.49	A	0.03	0.03	0.03	0.04	0.04	0.03	0.05	0.03	0.04	0.01	0.02	0.01	0.01	0.01	0.01	0.01
	B	0.12	0.09	0.09	0.12	0.15	0.10	0.13	0.16	0.14	0.04	0.02	0.03	0.05	0.03	0.03	0.05
	C	0.07	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.05	0.02	0.02	0.02	0.04	0.05	0.05	0.03
	D	0.07	0.04	0.04	0.05	0.08	0.05	0.06	0.08	0.07	0.02	0.04	0.03	0.03	0.04	0.04	0.04
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0.35	0.20	0.14	0.14	0.23	0.17	0.28	0.49	0.53	0.32	0.23	0.33	0.47	0.44	0.33	0.24
2.63	A	0.07	0.07	0.07	0.06	0.12	0.09	0.09	0.10	0.07	0.03	0.03	0.02	0.02	0.02	0.02	0.03
	B	0.25	0.25	0.24	0.30	0.44	0.37	0.55	0.57	0.40	0.06	0.08	0.07	0.06	0.04	0.08	0.13
	C	0.34	0.28	0.26	0.27	0.33	0.30	0.41	0.45	0.40	0.09	0.06	0.06	0.12	0.09	0.11	0.18
	D	0.55	0.33	0.31	0.27	0.42	0.36	0.51	0.54	0.55	0.17	0.13	0.15	0.22	0.25	0.26	0.31
	E	0.39	0.19	0.17	0.17	0.28	0.38	0.55	0.76	0.93	0.40	0.35	0.42	0.55	0.47	0.39	0.25
	F	0.94	0.46	0.26	0.23	0.46	0.50	0.79	1.56	2.03	0.97	0.69	1.01	1.51	1.39	0.95	0.69
4.27	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0.20	0.11	0.11	0.10	0.19	0.25	0.39	0.41	0.35	0.06	0.02	0.03	0.05	0.02	0.03	0.08
	C	0.72	0.31	0.17	0.17	0.42	0.49	1.08	1.25	0.98	0.12	0.11	0.14	0.20	0.11	0.17	0.31
	D	1.17	0.42	0.39	0.39	0.57	0.74	1.46	1.88	1.68	0.43	0.39	0.53	0.64	0.41	0.48	0.79
	E	0.55	0.16	0.12	0.15	0.21	0.33	0.87	1.37	2.22	0.98	0.63	1.07	1.52	1.14	0.56	0.42
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.64	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0.15	0.05	0.02	0.02	0.09	0.17	0.40	0.31	0.29	0.04	0.04	0.10	0.20	0.05	0.05	0.10
	D	1.48	0.43	0.30	0.26	0.48	0.64	1.98	1.76	1.30	0.39	0.40	1.32	2.32	0.77	0.61	1.29
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.53	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0.02	0	0	0	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.04	0.15	0.01	0	0.02
	D	0.29	0.07	0.02	0.02	0.04	0.07	0.23	0.11	0.09	0.10	0.12	0.51	1.29	0.23	0.14	0.35
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.88	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0.02	0.05	0.01	0	0
	D	0.07	0.01	0.01	0	0	0.01	0.03	0.02	0.02	0.02	0.02	0.21	0.67	0.08	0.03	0.05
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Data Source: NOAA 1995. Carlsbad, New Mexico, airport meteorological data (1990-1994)

Table F-8
WIPP Stack Release Parameters

Parameter[a]	Waste Handling Building	Exhaust Filter Building
Stack height (meters)	14.9	8.2
Stack diameter (meters)	2.4	4.4
Release velocity (cubic meters per second)	170	200
Effluent temperature (degrees Fahrenheit) (DOE 1995a)	61	61
Number of stacks	1	2

[a] DOE 1990, unless otherwise indicated

Table F-9
MEI and Noninvolved Worker Locations for Lag Storage Operations

Site	Noninvolved Worker Location	MEI Location
Hanford 200-East	100 meters south	16,000 meters east
Hanford 200-West	100 meters south	24,000 meters east
INEL	100 meters south	12,000 meters south-southeast
LANL	100 meters west	2,400 meters east-southeast
RFETS	300 meters north	5,000 meters north
ORNL	100 meters southwest	4,000 meters southwest
SRS	100 meters west-southwest	12,000 meters west-southwest

F.2.3 Exposure Scenarios

Exposure scenarios define a set of conditions and assumptions under which populations and/or individuals may be impacted by radioactive material or hazardous chemicals. Exposures scenarios that may result from the routine release of radionuclides and VOCs at the storage sites and at WIPP are described below.

Human health impacts from routine, chronic exposures to VOCs and gaseous radionuclides were evaluated for the public, noninvolved workers, and involved workers. Inhalation would be the primary exposure pathway for such releases; however, impacts to involved workers from external radiation during waste handling were also evaluated. Thermal treatment of waste to meet LDRs under Action Alternative 2 and No Action Alternative 1 would destroy the VOCs in the waste, so releases of hazardous chemicals would not occur during routine operations for these alternatives. It was assumed that members of the public were exposed continuously (8,766 hours per year) while noninvolved workers were exposed for 2,000 hours per year.

Human health impacts were evaluated over a lifetime of exposure for members of the public, workers, and the MEI. The MEI was assumed to be exposed at the same location for the full 35-year operational period of the Proposed Action and No Action Alternative 2 and for a 70-year lifetime for Action Alternatives 1, 2, and 3. The average exposure period for the population was assumed to be 35 years for all alternatives to account for population turnover. Working lifetimes for involved and noninvolved workers were assumed to be 35 years for all alternatives.

F.2.3.1 Storage Site Exposure Scenarios

Storage site impact estimates were based on impacts at the six major storage sites: the Hanford Site (Hanford), INEL, Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), RFETS, and Savannah River Site (SRS), where at least 98 percent of the waste would be stored under all alternatives. To estimate human health impacts to the population, MEI, noninvolved worker population, and the maximally exposed noninvolved worker from gaseous radionuclide and VOC emissions from storage facilities at consolidation sites, it was conservatively assumed that all drum-equivalents of treated waste were in storage beginning the first year of operations. It was assumed that the total number of drum-equivalents would emit VOCs over the lifetime of the exposed receptors. The population data for the consolidation sites were the same as those used for the Draft WM PEIS (DOE 1995c), which used data from the 1990 U.S. Census to estimate the population in 80-kilometer (50-mile) areas around the major storage sites. It was assumed that the populations surrounding all sites would remain at the 1990 levels. The

noninvolved worker population numbers for the storage sites were the same as those presented in the Draft WM PEIS (DOE 1995c).

Radiological impacts to the involved worker would primarily result from external radiation; exposure to gaseous radionuclides would be a negligible contributor. Specific information on estimating involved worker external dose impacts is presented in Section F.2.3.3 below.

An estimate of the impacts to the involved worker from VOC exposure during routine operations was made by assuming that each VOC would be present at its highest allowable concentration. This concentration was based on the EPA limits of 1×10^{-6} annual probability of cancer incidence for a Class B hazardous chemicals and 1×10^{-5} annual probability of cancer incidence for a Class C hazardous chemicals. Workers at each site were assumed to be exposed for a 35-year occupational lifetime.

F.2.3.2 WIPP Disposal Exposure Scenarios

Impacts to the public and noninvolved workers were evaluated for routine releases of gaseous radionuclides and VOCs from TRU waste at WIPP. For the exposure scenarios, it was assumed that all waste was contained in drums, using "drum-equivalents" to recognize that some waste may be in standard waste boxes (SWB). The releases from the underground area were estimated on a panel basis. Only one panel would be fully ventilated and unsealed at a time. It was assumed to require approximately 2 years (3 years for the Proposed Action) to fill a single panel with a total of approximately 81,000 drum-equivalents of CH-TRU waste and approximately 4,000 drum-equivalents of RH-TRU waste. Impacts were conservatively estimated by assuming that a full panel would continuously emit gaseous radionuclides and VOCs each year of operations. This assumption approximately doubles the actual emission estimate of VOCs from CH-TRU waste drums. A maximum number of drums (42 CH-TRU and 3 RH-TRU drum-equivalents) were assumed to be in the WHB at all times. As noted above, there would be no release of VOCs under Action Alternative 2 or No Action Alternative 1.

1990 U.S. Census data were used to determine the population inhabiting the 80-kilometer (50-mile) region surrounding WIPP. Approximately one-third of this population is located at Carlsbad, 42 kilometers (26 miles) west of WIPP, and one-third of the population is located at Hobbs, 72 kilometers (45 miles) east-northeast of WIPP (Table F-10). Population distributions would change unpredictably over the operations time frames evaluated in SEIS-II. For the purposes of impact analyses, it was assumed that the population surrounding WIPP would remain at 1990 levels.

The location of the MEI was set at the point on the WIPP site boundary where an individual could establish a residence, with the least amount of atmospheric dispersion. This location was determined to be 3,000 meters (9,840 feet) north of the Exhaust Filter Building.

Similarly, the location of the maximally exposed noninvolved worker at WIPP was determined by identifying the onsite location (i.e., within the Exclusive Use Area) with the minimum amount of atmospheric dispersion. This location was 200 meters (660 feet) east of the Exhaust Filter Building; outside of the property protection zone and north of the railroad spur. It is unlikely that an individual would be located at this site, but the impacts here would bound any onsite

Table F-10
1990 Population Distribution Within 80 Kilometers (50 Miles) of WIPP

Direction	Distance (miles)										Total
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	
S	0	0	0	0	0	0	3	2	46	20	**71**
SSW	9	0	0	0	0	0	0	2	43	8	**62**
SW	0	0	0	0	0	0	37	57	0	5	**99**
WSW	0	0	0	0	0	0	1,622	191	57	62	**1,932**
W	0	0	0	0	0	0	138	25,291	197	3	**25,629**
WNW	0	0	0	0	0	0	38	5,765	242	63	**6,108**
NW	0	0	0	0	0	0	6	7	14	12,401	**12,428**
NNW	0	0	0	0	0	9	4	66	104	56	**239**
N	0	0	0	0	0	0	3	0	63	12	**78**
NNE	0	0	0	0	0	0	4	3	122	7,353	**7,482**
NE	0	0	0	0	0	0	0	11	37	9,115	**9,163**
ENE	0	0	0	0	0	0	0	10	282	30,877	**31,169**
E	0	0	0	0	0	0	6	5	2,982	19	**3,012**
ESE	0	0	0	0	0	0	0	16	2,173	97	**2,286**
SE	0	0	0	0	0	0	0	0	15	20	**35**
SSE	0	0	0	0	0	1	3	14	5	73	**96**
Total	**9**	**0**	**0**	**0**	**0**	**10**	**1,864**	**31,440**	**6,382**	**60,184**	**99,889**

Source: DOE 1995d

noninvolved worker impacts. For impacts to the noninvolved worker population at WIPP, it was conservatively assumed that all 1,095 WIPP workers would be exposed at the same level as the maximally exposed noninvolved worker.

Involved workers at WIPP were evaluated according to two different waste-handling groups, those in the WHB and those in the underground area. This approach was necessary to estimate VOC impacts because of the considerable differences in the number of containers emitting VOCs to the ventilation air.

CH-TRU waste is handled in the WHB in a large, open area. The WHB exhaust operates at 43 cubic meters (1,505 cubic feet) per second (DOE 1990). WHB air exchange rates range from 1.5 to 12 per hour. Assuming that an air exchange rate of 12 per hour applies to the 43 cubic meters per second flow rate, an air exchange rate of 1.5 would correlate to a flow rate of 5.4 cubic meters (190 cubic feet) per hour. The minimum flow rate, 5.4 cubic meters (190 cubic feet) per second, was conservatively used to estimate impacts to the WHB worker. The underground flow rate was assumed to be 100 cubic meters (3,500 cubic feet) per second, which is the flow rate of only one of the two exhaust fans that drive the underground ventilation. The external radiation dose received by involved workers is considerably greater than the internal radiation dose from gaseous releases of radionuclides. Therefore, only the external doses were calculated.

F.2.3.3 External Radiation Dose of Involved Workers

The primary source of radiological impacts to involved workers at storage sites and at WIPP would be from external radiation exposures. During routine operations, only involved workers would be exposed to external radiation emitted from the waste. The results presented in the *Waste Isolation Pilot Plant Safety Analysis Report* (DOE 1995b) indicate that the expected annual external dose to

RH-TRU waste workers would be approximately 20 percent of that to CH-TRU waste workers during the time when both CH-TRU and RH-TRU waste is being disposed of. Based on this analysis, only the dose to CH-TRU workers was evaluated in detail. To determine the comparative radiological impact to workers for each alternative, screening calculations were performed to determine which radionuclides would be the primary contributors to external radiation dose. Alternative-specific variables included the volume of the Basic Inventory and Additional Inventory considered for storage or disposal and the waste density. WIPP worker radiological impact calculations were performed by using the radionuclide inventories of Appendix A. Dose rate reduction over time due to radioactive decay was not considered.

To identify the primary radionuclides contributing to external dose, the radionuclide-specific air immersion dose-rate factor (DOE 1988a) was multiplied by the radionuclide inventory for each site to determine an *external dose screening value*. These values do not have meaning as an expression of absolute impact, but do indicate the comparative impact from external dose for each radionuclide in the TRU waste. For example, if radionuclide A has a higher screening value than radionuclide B, an individual would receive a greater external dose from radionuclide A, all exposure conditions being equal.

External dose screening values were calculated for the entire CH-TRU waste radionuclide inventory to be sent to WIPP and for each consolidation site. The radionuclides that contributed at least 90 percent of the site's total screening value for the Proposed Action and each alternative are tabulated in Tables F-11 through F-15. The percentage of the site's total screening values contributed by the listed radionuclides, the DOE (1988a) nuclide-specific external dose factor, and the total screening value of all the radionuclides in each site's consolidated waste are shown in the tables.

Eight radionuclides were found to contribute the majority of the worker external dose for the sites evaluated. Americium-241 and barium-137m (the short-lived progeny of cesium-137) were found to be the largest individual contributors. Under most of the alternatives, waste consolidated at INEL and RFETS contains the majority of the americium-241, and waste consolidated at Hanford contains the majority of the barium-137m.

Table F-11
Proposed Action External Dose Screening Values for CH-TRU Waste[a, b]

Radionuclide	Ext DF[c]	Hanford	INEL	LANL	LLNL	Mound	NTS	ORNL	ANL-E	RFETS	SRS	All Sites
Cobalt-60	1.3E+4	---	9.7E+5	---	---	---	---	---	---	---	---	---
Barium-137m	3.1E+3	1.1E+7	---	3.2E+5	---	---	---	---	---	---	3.4E+4	1.2E+7
Europium-152	5.9E+3	---	---	---	---	---	7.5E+3	---	---	---	---	---
Europium-154	6.5E+3	---	---	---	---	---	3.4E+3	---	---	---	---	---
Bismuth-214	8.1E+3	---	---	---	---	---	2.4E+3	8.0E+4	---	---	---	---
Neptunium-239	840	---	---	---	---	---	---	1.9E+4	1.7E+3	---	---	---
Plutonium-238	0.44	---	---	---	---	280	1.7E+4	---	---	---	3.8E+5	---
Americium-241	95	2.5E+6	1.0E+7	2.5E+6	8.4E+4	---	3.3E+4	2.6E+5	1.2E+4	2.2E+7	3.0E+5	3.8E+7
Total		1.4E+7	1.2E+7	3.0E+6	8.5E+4	290	6.8E+4	4.0E+5	1.4E+4	2.2E+7	7.6E+5	5.2E+7
Percent Total Site Value		98	94	93	98	99	93	90	94	99	92	95

[a] Dashed lines indicate a negligible contributor to the external dose from a site's average waste.
[b] Screening values are unitless and are useful for comparative purposes.
[c] External dose conversion factor.

Table F-12
Action Alternative 1 External Dose Screening Values for CH-TRU Waste[a, b]

Radionuclide	Ext DF[c]	Hanford	INEL	LANL	LLNL	Mound	NTS	ORNL	ANL-E	RFETS	SRS	All Sites
Cobalt-60	1.3E+4	---	2.5E+6	---	---	---	---	---	---	---	---	---
Barium-137m	3.1E+3	1.9E+7	---	4.4E+5	---	---	---	1.7E+4	---	---	4.0E+4	2.0E+7
Europium-152	5.9E+3	---	---	---	---	---	6.4E+3	---	---	---	---	---
Europium-154	6.5E+3	---	---	---	---	---	2.8E+3	---	---	---	---	---
Bismuth-214	8.1E+3	---	---	---	---	---	2.1E+3	7.0E+4	---	---	---	---
Neptunium-239	840	---	---	---	---	---	---	1.7E+4	870	---	---	---
Plutonium-238	0.44	---	---	---	---	240	1.4E+4	---	---	---	4.5E+5	---
Americium-241	95	4.4E+6	2.6E+7	3.5E+6	7.1E+4	---	2.8E+4	2.6E+5	6.3E+3	2.0E+7	3.5E+5	5.5E+7
Total		2.4E+7	3.0E+7	4.3E+6	7.2E+4	240	5.7E+4	4.0E+5	1.2E+4	2.0E+7	9.1E+5	8.0E+7
Percent Total Site Value		98	95	93	98	99	93	91	94	99	9	94

[a] Dashed lines indicate a negligible contributor to the external dose from a site's average waste.
[b] Scoping values are unitless and are useful for comparative purposes.
[c] External dose conversion factor.

Table F-13
Action Alternative 2A, Action Alternative 3, and No Action Alternative 1A External Dose Screening Values for CH-TRU Waste[a, b, c]

Radionuclide	Ext DF[d]	Hanford	INEL	LANL	RFETS	SRS	All Sites
Cobalt-60	1.3E+4	---	2.5E+6	---	---	---	---
Barium-137m	3.1E+3	1.9E+7	---	4.4E+5	---	5.7E+4	2.0E+7
Bismuth-214	8.1E+3	---	---	---	---	7.0E+4	---
Plutonium-238	0.44	---	---	---	---	4.5E+5	---
Americium-241	95	4.5E+6	2.6E+7	3.5E+6	2.0E+7	6.2E+5	5.5E+7
Total		2.4E+7	3.0E+7	4.3E+6	2.0E+7	1.3E+6	8.0E+7
Percent Total Site Value		98	95	93	99	91	94

[a] Dashed lines indicate a negligible contributor to the external dose from a sites average waste.
[b] Screening values are unitless and are useful for comparative purposes.
[c] Action Alternative 2C screening values are equivalent to the "All Sites" values.
[d] External dose conversion factor.

Table F-14
Action Alternative 2B and No Action Alternative 1B External Dose Screening Values for CH-TRU Waste[a, b]

Radionuclide	Ext DF[c]	Hanford	INEL	SRS	All Sites
Bismuth-214	8.1E+3	---	---	7.0E+4	---
Barium-137m	3.1E+3	1.9E+7	---	5.7E+4	2.0E+7
Americium-241	95	4.5E+6	5.0E+7	6.2E+5	5.5E+7
Plutonium-238	0.44	---	---	4.5E+5	---
Total		2.4E+7	5.5E+7	1.3E+6	8.0E+7
Percent Total Site Value		98	91	91	94

[a] Dashed lines indicate a negligible contributor to the external dose from a site's average waste.
[b] Screening values are unitless and are useful for comparative purposes.
[c] External dose conversion factor.

Table F-15
No Action Alternative 2 External Dose Screening Values for CH-TRU Waste[a, b]

Radionuclide	Ext DF[c]	Hanford	INEL	LANL	LLNL	Mound	NTS	ORNL	ANL-E	RFETS	SRS	All Sites
Cobalt-60	1.3E+4	---	8.2E+5	---	---	---	---	---	---	---	---	---
Barium-137m	3.1E+3	9.3E+6	---	2.7E+5	---	---	---	1.0E+4	---	---	4.3E+4	9.8E+6
Europium-152	5.9E+3	---	---	---	---	---	6.4E+3	---	---	---	---	---
Europium-154	6.5E+3	---	---	---	---	---	2.8E+3	---	---	---	---	---
Bismuth-214	8.1E+3	---	---	---	---	---	2.1E+3	6.8E+4	---	---	---	---
Neptunium-239	840	---	---	---	---	---	---	1.6E+4	1.4E+3	---	---	---
Plutonium-238	0.44	---	---	---	---	---	1.4E+4	---	---	---	4.9E+5	---
Americium-241	95	2.1E+6	8.7E+6	2.1E+6	7.1E+4	240	2.8E+4	2.2E+5	9.8E+3	2.0E+7	3.8E+5	3.4E+7
Total		1.2E+7	1.0E+7	2.6E+6	7.2E+4	240	5.7E+4	3.5E+5	1.2E+4	2.0E+7	9.8E+5	4.6E+7
Percent Total Site Value		98	94	93	98	99	93	92	94	99	92	95

[a] Dashed lines indicate a negligible contributor to the external dose from a site's average waste.
[b] Screening values are unitless and are useful for comparative purposes.
[c] External dose conversion factor.

External dose estimates were made for involved workers using the radionuclides indicated by the screening calculations. Although americium-241 and barium-137m would be responsible for the majority of the potential external dose, cobalt-60 would be an important potential contributor for INEL-consolidated waste; bismuth-214 and neptunium-239 would be important for ORNL-consolidated waste; and plutonium-238 and bismuth-214 would be notable for SRS-consolidated waste. Therefore, external dose impacts were calculated by including americium-241, barium-137m, cobalt-60, bismuth-214, neptunium-239, and plutonium-238.

Involved workers may receive radiation doses either during WIPP disposal operations or during storage operations at consolidation sites. During the years of maximum impact (for the action alternatives), when both CH-TRU and RH-TRU waste would be disposed of, a greater impact would be expected for CH-TRU waste handling than for RH-TRU waste handling because RH-TRU waste would be managed remotely, and the exposure conditions limited by distance, shielding, and additional administrative controls contained in the *WIPP Radiological Control Manual* (DOE 1995d). Although the RH-TRU waste container external dose rates would be higher than those for CH-TRU waste, worker exposures from the routine disposal of RH-TRU waste would generally be less because of remote handling operations and the smaller volume of waste. Even so, there are no differences in the maximum annual dose limit for CH-TRU and RH-TRU workers.

The external radiation dose received from handling CH-TRU waste containers would be a function of the radionuclides present, the quantity of each radionuclide, and the waste density. The quantity of radionuclides in a container may be reduced as a result of packaging in order to meet WAC or TRUPACT-II acceptance criteria prior to being sent to WIPP. The packaging of individual waste containers would be done to meet dose-rate, weight, thermal power, or PE-Ci limitations (see Table F-16). These limits result from the design criteria for WIPP operations and TRUPACT-II acceptance (DOE 1996b). Thermal power and weight limits were taken into account when estimates of shipment volumes and emplacement volumes were determined. Therefore, only a small volume of waste would require packaging.

Table F-16
Specific Planning-Basis WAC Requirements Limiting Waste Container Radionuclide Contents

Administrative Control	Limit	Comment
Container external dose rate	CH-TRU surface: 200 mrem/hour RH-TRU surface: no more than 5 percent of the RH-TRU canisters are allowed dose rates of greater than 100 rem/hour	Dose rate 2 meters from the TRUPACT-II must be less than 10 mrem/hour
Container PE-Ci content	80 PE-Ci for CH-TRU drum 130 PE-Ci for CH-TRU Standard Waste Box 1,800 PE-Ci for solidified or vitrified waste or overpacked drum 1,000 PE-Ci for RH-TRU canister	TRUPACT-II transport container limits restrict the fissile gram equivalents (FGEs) to 325 FGEs per TRUPACT-II, with a maximum of 200 FGEs/drum. These restrictions further limit the PE-Ci content of the container.
Container thermal power limit	Thermal power limit for the contents of a TRUPACT-II is 40 watts.	- - -

The external radiation dose to a worker can also be reduced through radiation protection practices such as radiation shielding within the drum or placing the highest external-dose-rate container in a seven-drum bundle in the interior bundle location. Waste manifests require record of the maximum package dose rate, so external doses can be knowledgeably limited by administrative controls. When practiced, these procedures would lead to small annual reductions in external exposures but would accumulate to substantial reductions over time. For the purposes of SEIS-II impact analyses, however, these practices were not considered when estimating worker doses.

The WIPP annual occupational dose limit is currently 1.0 rem per year TEDE (DOE 1995d). Doses to extremities (i.e., hands) are limited to 50 rem per year. In addition, the *WIPP Radiological Control Manual* (DOE 1995d) contains the WIPP As Low As Reasonably Achievable (ALARA) radiation protection policy, which is an administrative check of worker exposures.

Surface and 1-meter (3.3-foot) dose rates for average CH-TRU waste drums are presented in Table F-17 for the major storage sites and for WIPP. The 1995 activity of the waste was used for dose rate estimates, and drum surface dose rates were calculated according to the following equation:

$$S_{icd} = Did \times Cic \qquad \text{(Equation F-1)}$$

where

S_{icd} = surface dose rate from a drum with radionuclide "i" for waste at consolidation site "c" with a waste density "d" in units of rem per hour

D_{id} = surface dose rate of a drum with 1 Ci of radionuclide "i" and a waste density "d" in units of rem per hour per Ci per drum

C_{ic} = activity of radionuclide "i" in Ci for an average drum at consolidation site "c"

The total surface dose rate of consolidation site waste was calculated by summing the S_{icd} values for the radionuclides of concern. The 1-meter (3.3-foot) dose rates were calculated in a similar manner, using the 1-meter (3.3-foot) dose rate value for the D_{id} variable.

Table F-17
Average Surface Dose Rate of CH-TRU Waste Drums

Alternative	Waste Treatment	Site	Waste Package Density (grams/cubic meter)	Average Surface Dose Rate (mrem/hour)	Average 1-meter Dose Rate (mrem/hour)
Proposed Action	WAC	WIPP	0.582	40	2.9
Action Alternative 1	WAC	Lag-Hanford	0.592	34	2
		Lag-INEL	0.598	31	3
		Lag-LANL	0.720	9	0.7
		Lag-RFETS	0.153	153	13
		Lag-ORNL	0.259	33	3
		Lag-SRS	0.476	4	0.3
		WIPP	0.582	32	2.3
Action Alternative 2A & No Action Alternative 1A	LDR	Lag-Hanford	1.966	42	2
		Lag-INEL	1.966	13	1
		Lag-LANL	1.966	6	0.5
		Lag-RFETS	1.966	57	5
		Lag-SRS	1.966	3	0.3
		WIPP	1.966	25	1.6
Action Alternative 2B & No Action Alternative 1B	LDR	Lag-Hanford	1.966	42	2
		Lag-INEL	1.966	15	1
		Lag-SRS	1.966	3	0.3
		WIPP	1.966	25	1.6
Action Alternative 2C	LDR	WIPP	1.966	25	1.6
Action Alternative 3	Shred and grout	Lag-Hanford	1.375	17	0.9
		Lag-INEL	1.281	8	0.6
		Lag-LANL	1.224	3	0.2
		Lag-RFETS	0.631	36	3
		Lag-SRS	1.058	2	0.1
		WIPP	1.256	12	0.7
No Action Alternative 2	WAC	Hanford	0.592	34	2
		INEL	0.621	30	3
		LANL	0.730	9	0.8
		RFETS	0.369	200[a]	21
		ORNL	0.259	33	2
		SRS	0.476	6	0.4

[a] Calculated surface dose rate was 242 mrem per hour for RFETS. Individual waste containers exceeding limits would be repackaged or internally shielded to meet the planning-basis WAC limit of 200 mrem per hour surface dose rate for CH-TRU waste. This packaging would subsequently reduce the 1-meter dose rate.

WIPP Involved Workers

It was assumed that involved workers at WIPP would be exposed depending upon the time needed to dispose of CH-TRU waste but for no more than 35 years. Alternative-specific occupational lifetime dose estimates were calculated as follows:

- The number of years required for the most efficient placement of CH-TRU waste in a single panel were calculated. Efficient placement maximizes annual exposures to radioactive material and hazardous chemicals. Because of thermal power limitations, the number of drum-equivalents in a panel under Action Alternative 2 would be approximately half that of the other alternatives that include waste disposal at WIPP. Therefore, it was assumed that a panel-full of CH-TRU waste would be disposed of in one year under Action Alternative 2 and two years under the other alternatives. For the Proposed Action, an effective operations time of two years was assumed for the disposal of CH-TRU waste in panels even though the panels would be open for an average of 3.5 years. The effective

operations time accounts for the time it would take to gear up to the most efficient operations (e.g., manufacture of enough transport vehicles and containers to operate most efficiently and training of consolidation site personnel to adequately certify that the waste meets the WAC). Ramping up the operations would predominantly impact the early operations period.

- Radiation doses to the waste handling workers at WIPP were estimated for disposal operations under each alternative. It was assumed that workers would be 1 meter (3.3 feet) from the waste for 2 hours per day, 4 days per week, 50 weeks per year; a total of 400 hours per year.

- Average 1-meter (3.3-foot) dose rates were assumed for waste drums, as shown in Table F-17.

Impacts to involved workers at WIPP were determined on a per panel basis. Using the above assumptions, WIPP involved worker doses per panel were calculated using Equation F-2.

$$D_A = d_A \times (Y_{A,I}) \times 400/1{,}000 \qquad \text{(Equation F-2)}$$

where

D_A = worker lifetime occupational external dose per panel from CH-TRU operations for alternative "A", in rem

d_A = average 1-meter (3.3-foot) dose rate from CH-TRU waste for alternative "A", in mrem per hour (from Table F-17 for WIPP)

$Y_{A,I}$ = the time required for CH-TRU operations per panel under alternative "A" for inventory "I" (Basic Inventory or Total Inventory). The value is 2 years per panel for the Proposed Action, Action Alternative 1, and Action Alternative 3 and 1 year per panel for Action Alternative 2

400 = is the exposure time at 1 meter (3.3 feet) from the CH-TRU waste drums; in hours per year

1,000 = mrem per rem

Lifetime radiation doses for workers at WIPP were then calculated using the results of Equation F-2 and the number of panels in which CH-TRU waste would be emplaced, for each action alternative. Table F-18 presents the D_A values, the number of panels, and the years of operations used to estimate the involved worker radiation doses under the Proposed Action and Action Alternatives 1, 2, and 3. The number of panels that an individual worker or a specific involved worker population were assumed to work with were limited by the effective time of operations because the total time of occupational exposure was limited to 35 years. The calculated D_A for the Proposed Action was 2.4 rem and the calculated dose to a worker for the 20-year effective operations period needed to fill 10 panels was 1.2 rem per year, which exceeds the WIPP administrative dose limit. Therefore, the D_A was limited to 2.0 so that the administrative dose limit would not be exceeded. For Action Alternative 2, all CH-TRU waste could be disposed of in 12.8 effective working years.

Table F-18
Parameters Used in Calculating WIPP Involved Worker Lifetime Radiation Dose from Routine CH-TRU Waste Disposal Operations

Parameter	Proposed Action	Action Alternative 1	Action Alternative 2	Action Alternative 3
Dose per CH-TRU Waste Panel, DA (rem)	2.0 (2.4)	1.9	0.63	0.60
Years of CH-TRU Panel Operations				
Basic Inventory	20[a]	17	5.7	20
Total Inventory	N/A	33.4	12.8	35
Panels of CH-TRU Waste				
Basic Inventory	10	8.5	5.7	10.0
Total Inventory	10	16.7	12.8	19.8

[a] Effective years of disposal operations, assuming approximately 2 years of effective disposal operations time per panel.

Storage Site Involved Workers - Routine Handling and Monitoring

Radiological impacts to involved workers at CH-TRU waste storage facilities would result from the handling and monitoring of CH-TRU waste. Under No Action Alternative 1, however, radiological impacts would result mainly from routine overpacking of CH-TRU waste and were evaluated separately. The radiological impact to the individual worker was assumed to be bounded by site-specific occupational dose limits. The TEDE received by an individual worker cannot exceed 5 rem per year (10 CFR Part 835) and may be more restrictive at any of the DOE sites.

Because the amount of CH-TRU waste in storage will vary over time, the number of workers required to manage the waste would vary accordingly. Other site variables are as follows: the design of storage facilities, the amount of waste handling automation, monitoring activities, and waste handling procedures. Table F-19 presents involved worker population estimates at the storage sites under Action Alternatives 1, 2, and 3, and No Action Alternative 2.

To develop radiological impact estimates for storage facility workers, uniform assumptions were applied across all CH-TRU waste storage operations. Individual worker impacts were determined by assuming that exposures occurred at 1 meter (3.3 feet) from CH-TRU waste for 2 hours per day, 5 days per week, 50 weeks per year over the entire 35-year career of the worker. The radionuclides identified as the primary contributors to external doses in the CH-TRU inventory were used to determine the 1-meter (3.3-foot) dose rates. These radionuclides were decayed over the 35-year exposure period.

The entire storage worker population was assumed to be exposed in the same manner as was the individual worker. Worker populations were estimated by assuming that 20 percent of the total waste volume would be in the storage facility each year and that each worker could manage 1,000 cubic meters of waste per year (see Equation F-3).

$$W_s = 0.2 \times V_{CH,s} \times T \qquad \text{(Equation F-3)}$$

where

W_s = worker population at site "s",

$V_{CH,s}$ = volume of CH-TRU waste at site "s" in cubic meters

T = worker throughput rate of one worker per 1,000 cubic meters

Table F-19
Storage Site Involved Worker Population Estimates

Site	Alternative	Total Worker Population	
		Basic Inventory	Total Inventory
Total	Action Alternative 1	28	28
	Action Alternative 2A	10	21
	Action Alternative 2B	9	21
	Action Alternative 3	33	67
	No Action Alternative 2	27	N/A
Hanford	Action Alternative 1	12	12
	Action Alternative 2A	4	9
	Action Alternative 2B	4	9
	Action Alternative 3	14	29
	No Action Alternative 2	12	N/A
INEL	Action Alternative 1	6	6
	Action Alternative 2A	2	8
	Action Alternative 2B	4	11
	Action Alternative 3	7	21
	No Action Alternative 2	6	N/A
LANL	Action Alternative 1	4	4
	Action Alternative 2A	1	2
	Action Alternative 2B	N/A	N/A
	Action Alternative 3	5	8
	No Action Alternative 2	4	N/A
RFETS	Action Alternative 1	3	3
	Action Alternative 2A	1[a]	1[a]
	Action Alternative 2B	N/A	N/A
	Action Alternative 3	4	4
	No Action Alternative 2	2	N/A
ORNL	Action Alternative 1	1[a]	1[a]
	Action Alternative 2A	N/A	N/A
	Action Alternative 2B	N/A	N/A
	Action Alternative 3	N/A	N/A
	No Action Alternative 2	1[a]	N/A
SRS	Action Alternative 1	2	2
	Action Alternative 2A	1	1
	Action Alternative 2B	1	1
	Action Alternative 3	3	5
	No Action Alternative 2	2	N/A

[a] Involved workers were assumed not to be involved in waste handling fulltime.

N/A = Not Applicable

The number of years of operations for the lag storage sites were assumed to be the maximum occupation exposure period of 35 years. For the action alternatives, this assumption removes the need to make highly uncertain assumptions regarding when each storage site will send the final amount of waste to WIPP. The results provide an upper bounding case for storage impacts to involved workers.

Overpacking Operations of No Action Alternative 1

Despite the variation in operations at each packaging facility, the impacts from overpackaging were calculated to provide a rough idea of how radiological impacts to the involved worker would compare across the consolidation sites under No Action Alternative 1. Overpacking impact estimates were determined by assuming identical waste handling at all consolidation sites. For impacts to the worker population, it was assumed that the average worker would be 1 meter

(3.3 feet) from the waste for 2 hours per day, 5 days per week, 50 weeks per year, and all individuals in the worker population would be involved in these operations over 35 years. The maximally exposed involved worker was assumed to be exposed for twice as long (4 hours per day). The average 1-meter (3.3-foot) dose rates were adjusted annually for radioactive decay; the greatest external dose rates would occur early in the operations period. Therefore, the maximum impacts to workers were estimated from year 20 to year 55 for storage operations because CH-TRU waste containers have a design life of 20 years. The annual occupational dose limit (TEDE) as regulated by Title 10 of the Code of Federal Regulations, Part 835 (10 CFR Part 835) is 5 rem and was assumed to apply to all packaging workers at the various sites.

The involved worker populations under No Action Alternative 1 were determined by assuming that 4.2 workers would be required to overpackage 12 drums a day. This level of overpackaging maximizes the worker population because worker personnel protection (e.g., workers have self-contained breathing apparatus and are fully suited-up) is maximized. The involved worker population required at each site for overpackaging operations, based on site-specific volumes of waste, are as follows for No Action Alternative 1A: 35 total workers with 14 at Hanford, 14 at INEL, 4 at LANL, 1 at RFETS, and 2 at SRS; and for No Action Alternative 1B: 35 total workers with 14 at Hanford, 19 at INEL, and 2 at SRS.

F.3 HUMAN HEALTH IMPACTS

The radiological and hazardous chemical impacts from TRU waste storage at the major consolidation sites and from WIPP disposal operations are presented in this section.

F.3.1 Radiological Impacts

Radiological impacts to the public and noninvolved workers at the storage sites and at WIPP may result from releases of gaseous radionuclides present in TRU waste containers. Radionuclides contributing to these impacts are carbon-14 and radon-222. Radiation doses are presented in Table F-20 and are well below background radiation levels. The radiological impacts of these doses, presented in Chapter 5, were estimated using ICRP 60 dose-to-risk factors.

Radiological impacts to involved workers at WIPP and the storage sites would be due to external radiation from the TRU waste containers. Table F-21 presents the radiological impacts to involved workers at WIPP from routine handling and disposal of waste containers for the Proposed Action and Action Alternatives 1, 2, and 3. Table F-22 presents the radiological impacts to involved workers at the major storage sites from routine handling and monitoring of waste containers for Action Alternatives 1, 2, and 3, and No Action Alternative 2. Table F-23 presents the radiological impacts to involved workers at the major storage sites from the overpacking of TRU waste containers during the long-term storage period for No Action Alternative 1.

F.3.2 Impacts from VOCs

The impacts of routine releases of VOCs from TRU waste containers at the major storage sites and WIPP were evaluated for the Proposed Action, Action Alternative 1, Action Alternative 3, and No Action Alternative 2. Waste would not be stored at sites under the Proposed Action, and no VOCs would be emitted under Action Alternative 2 and No Action Alternative 1 because of the thermal waste treatment.

Table F-20
Radiation Doses from Routine Releases of Gaseous Radionuclides [a, b]

Alternative	Hanford C-14	INEL Rn-222	LANL Rn-222	RFETS	ORNL Rn-222	SRS Rn-222	WIPP Rn-222
Proposed Action							
MEI (rem per 35 years)							5E-4
Population (person-rem per 35 years)	N/A	N/A	N/A	N/A	N/A	N/A	0.6
Noninvolved Worker (rem per 35 years)							1E-3
Action Alternative 1							
MEI (rem per 70 years)	2E-5	3E-6	1E-3	No known inventory for Rn-222 or C-14	3E-3	2E-10	9E-4
Population (person-rem per 35 years)	2E-1	1E-2	4E+0		2E+1	8E-6	6E-1
Noninvolved Worker (rem per 35 years)	3E-4	1E-4	2E-3		2E-2	2E-8	1E-3
Action Alternative 2A							
MEI (rem per 70 years)	7E-6	1E-6	3E-4	No known inventory for Rn-222 or C-14		2E-5	2E-4
Population (person-rem per 35 years)	1E-1	5E-3	1E+0		N/A	1E+0	1E-1
Noninvolved Worker (rem per 35 years)	2E-4	6E-5	6E-4			3E-3	4E-4
Action Alternative 2B							
MEI (rem per 70 years)	7E-6	9E-6				2E-5	2E-4
Population (person-rem per 35 years)	1E-1	3E-2	N/A	N/A	N/A	1E+0	1E-1
Noninvolved Worker (rem per 35 years)	2E-4	4E-4				3E-3	4E-4
Action Alternative 2C							
MEI (rem per 70 years)							2E-4
Population (person-rem per 35 years)	N/A	N/A	N/A	N/A	N/A	N/A	1E-1
Noninvolved Worker (rem per 35 years)							4E-4
Action Alternative 3							
MEI (rem per 70 years)	1E-5	3E-6	6E-4	No known inventory of Rn-222 or C-14		5E-5	5E-4
Population (person-rem per 35 years)	1E-1	1E-2	2E+0		N/A	2E+0	3E-1
Noninvolved Worker (rem per 35 years)	2E-4	1E-4	1E-3			5E-3	7E-4
No Action Alternative 2							
MEI (rem per 70 years)	2E-6	5E-7	7E-4	No known inventory of Rn-222 or C-14	3E-3	2E-10	
Population (person-rem per 35 years)	3E-2	2E-3	3E+0		2E+0	7E-6	N/A
Noninvolved Worker (rem per 35 years)	5E-5	2E-5	1E-3		2E-2	2E-8	

[a] Gaseous radionuclide is carbon-14 (C-14) or radon-222 (Rn-222).
[b] N/A indicates the site is not a consolidation site under the alternative.

Table F-21
WIPP Involved Worker Lifetime Radiological Impacts from Routine CH-TRU Waste Disposal Operations[a]

Impact	Proposed Action	Action Alternative 1	Action Alternative 2	Action Alternative 3
Worker Dose (rem)				
Basic Inventory	20	15.7	3.6	5.9
Total Inventory	N/A	30.9	8.1	10.4
Probability of LCF				
Basic Inventory	8E-3	6E-3	1E-3	2E-3
Total Inventory	N/A	0.01	3E-3	4E-3
Worker Population Dose (person-rem) (36 workers)				
Basic Inventory	720	570	130	210
Total Inventory	N/A	1,100	290	370
Number of LCFs				
Basic Inventory	0.29	0.23	0.052	0.084
Total Inventory	N/A	0.4	0.12	0.15

[a] Effective years of disposal operations, assuming approximately 2 years of effective disposal operations time per panel.

N/A = Not Applicable

Table F-22
Storage Site Involved Worker Lifetime Radiological Impacts

Site	Alternative	Individual Dose (rem)	Percent Probability of an LCF	Population Dose (person-rem)		Number of LCFs in the Population	
				Basic Inventory	Total Inventory	Basic Inventory	Total Inventory
Hanford	Action Alternative 1	24	0.01	279	279	0.1	0.1
	Action Alternative 2A	29	0.01	119	247	0.05	0.1
	Action Alternative 2B	29	0.01	119	247	0.05	0.1
	Action Alternative 3	11	4E-03	162	334	0.06	0.1
	No Action Alternative 2	24	0.01	279	N/A	0.1	N/A
INEL	Action Alternative 1	40	0.02	241	241	0.1	0.1
	Action Alternative 2A	13	5E-03	26	104	0.01	0.04
	Action Alternative 2B	16	6E-03	71	189	0.03	0.08
	Action Alternative 3	8	3E-03	57	161	0.02	0.06
	No Action Alternative 2	39	0.02	225	N/A	0.09	N/A
LANL	Action Alternative 1	12	5E-03	52	52	0.02	0.02
	Action Alternative 2A	7	3E-03	10	17	4E-03	7E-03
	Action Alternative 2B	N/A	N/A	N/A	N/A	N/A	N/A
	Action Alternative 3	3	1E-03	16	27	6E-03	0.01
	No Action Alternative 2	12	5E-03	51	N/A	0.02	N/A
RFETS	Action Alternative 1	222	0.09	764	764	0.3	0.3
	Action Alternative 2A	89	0.04	68	23	0.03	9E-03
	Action Alternative 2B	N/A	N/A	N/A	N/A	N/A	N/A
	Action Alternative 3	56	0.02	209	209	0.08	0.08
	No Action Alternative 2	352	0.1	764	N/A	0.3	N/A
ORNL	Action Alternative 1	32	0.01	12	12	5E-03	5E-03
	Action Alternative 2A	N/A	N/A	N/A	N/A	N/A	N/A
	Action Alternative 2B	N/A	N/A	N/A	N/A	N/A	N/A
	Action Alternative 3	N/A	N/A	N/A	N/A	N/A	N/A
	No Action Alternative 2	7	3E-03	3	N/A	1E-03	N/A
SRS	Action Alternative 1	5	2E-03	11	11	4E-03	4E-03
	Action Alternative 2A	3	1E-03	3	4	1E-03	2E-03
	Action Alternative 2B	3	1E-03	3	4	1E-03	2E-03
	Action Alternative 3	1	4E-04	5	7	2E-03	3E-03
	No Action Alternative 2	2	8E-04	4	N/A	2E-03	N/A

N/A = Not Applicable

Table F-23
Storage Site Involved Worker Lifetime Radiological Impacts Under No Action Alternative 1

	No Action Alternative 1A				No Action Alternative 1B			
	Maximally Exposed Worker		Worker Population		Maximally Exposed Worker		Worker Population	
Site	Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs	Dose (rem)	Probability of an LCF	Dose (person-rem)	LCFs
Hanford	38	0.02	266	0.1	38	0.02	266	0.1
INEL	22	9E-3	154	0.06	30	0.01	285	0.1
LANL	12	5E-3	24	0.01	N/A	N/A	N/A	N/A
RFETS	172	0.07	86	0.03	N/A	N/A	N/A	N/A
SRS	5	2E-3	5	2E-3	5	2E-3	5	2E-3

N/A = Not Applicable

F.3.2.1 Proposed Action

Forty-two CH-TRU and three RH-TRU waste drum-equivalents were assumed to be constantly present in the WHB. All 45 drums were assumed to contain VOCs at the planning-basis WAC concentration limit or, where no specific limit was established, the weighted maximum VOC concentration. From the underground, a full single panel containing approximately 84,000 drum-equivalents of TRU waste (alternative-specific values indicated in Table F-6) was assumed to be continuously releasing VOCs every year. All drums in the underground area were assumed to contain the weighted average concentrations of VOCs. Panels would be sealed upon filling, therefore, no more than one panel would be open at any one time. All VOCs were assumed to be released to the atmosphere from the underground exhaust ventilation stack of the Exhaust Filter Building. WHB workers and the underground workers would be exposed to VOCs in the ventilation air; low ventilation rates were assumed to bound potential exposures.

The impacts, dominated by the releases from the underground area rather than from the WHB, are presented in Table F-24. The maximum HI resulting from the stack releases would be 6×10^{-4} (noninvolved worker) and 7×10^{-5} (MEI) from the carbon tetrachloride releases. An HI of one or greater to a member of the public would predict a noncarcinogenic health effect. WHB and underground area workers would have HIs greater than one for carbon tetrachloride, two (WHB) and six (underground). The HI for methylene chloride is 0.9 for the WHB workers.

Table F-24
Proposed Action Human Health Impacts from Routine Releases of VOCs at WIPP

Individual/Population	Lifetime Cancer Risk	Major Contributor (percent of total)	Maximum HI	VOC with Maximum HI
Noninvolved Worker	1E-7	1,1,2,2-tetrachloroethane (86)	6E-4	Carbon tetrachloride
35-year MEI	3E-8	1,1,2,2-tetrachloroethane (96)	7E-5	Carbon tetrachloride
50-mile Population	2E-5	1,1,2,2-tetrachloroethane (89)	N/A	N/A
WHB Worker	2E-4	1,2-dichloroethane (30)	2	Carbon tetrachloride
Underground Worker	9E-4	1,1,2,2-tetrachloroethane (86)	6	Carbon tetrachloride

N/A = Not Applicable

For these VOCs, the air concentration was compared to the OSHA PEL (see Table F-3). The air concentration for the workers would be at least 3 orders of magnitude less than the PELs, therefore, no involved worker noncarcinogenic health effects would be expected at WIPP from routine releases under the Proposed Action. A lifetime probability of cancer incidence of 1×10^{-7} (noninvolved worker) and 3×10^{-8} (MEI) may result from the routine releases of VOCs over the 35-year operating period. Annual risk would be 1/35 of the total values. No cancers would occur in the 80-kilometer (50-mile) population (2×10^{-5} cancers).

F.3.2.2 Action Alternative 1

The same assumptions used for the Proposed Action to analyze the impacts at WIPP were used for Action Alternative 1 impact analyses.

The impacts to the noninvolved worker, MEI, and populations at WIPP and the lag storage sites under Action Alternative 1 are presented in Table F-25. The maximum annual HI from stack releases of carbon tetrachloride would be 4×10^{-3} (noninvolved worker at INEL) and 6×10^{-4} (MEI at LANL or Hanford). No noncarcinogenic effects would be expected from the routine VOC releases under Action Alternative 1. Impacts to the involved workers in the WHB and the underground area would be the same under Action Alternative 1 as under the Proposed Action. The highest individual probabilities of cancer incidence estimated for the routine releases of hazardous chemicals were 5×10^{-7} (noninvolved worker at INEL) and 1×10^{-7} (MEI at Hanford, LANL, or ORNL). This would be the lifetime carcinogenic risk for the 35 years (noninvolved worker) and 70 years (MEI) to which the individual was conservatively assumed to be exposed. The maximum annual impact would be equivalent to 1/35th or 1/70th of the total noninvolved worker or MEI value, respectively. No cancers would be expected in the 80-kilometer (50-mile) population (maximum expected cancers over each 35-year period would be 1×10^{-3} for RFETS).

F.3.2.3 Action Alternative 2

No routine releases of VOCs would occur because VOCs in the waste would be destroyed during thermal treatment to meet the LDRs.

F.3.2.4 Action Alternative 3

Action Alternative 3 considers the treatment of the Basic and Additional Inventories of TRU waste by shred and grout. The VOC headspace concentrations are driven by the waste matrix, and the matrix of all Action Alternative 3 waste is a uniform solidified inorganic. As a result, all headspace concentrations for the waste at all consolidation sites were assumed to be identical.

The increased waste volume (as compared to WAC-packaged waste) resulting from the shred and grout process would require that more time be given to dispose of the waste. There is lag storage of waste at consolidation sites. Impacts at WIPP would be greatest in the early years of operations, when both the CH-TRU waste and RH-TRU waste are being disposed of. The maximum annual impacts were estimated using methods similar to those described for Action Alternative 1. It was conservatively assumed that the total number of drum-equivalents that a consolidation site would eventually send to WIPP would release VOCs into the atmosphere at the lag storage sites at the beginning of the operations period. It was also assumed that the MEI would be exposed to this release over a 70-year period, and the noninvolved worker and noninvolved worker population would be exposed over a 35-year period.

Table F-25
Action Alternative 1 Human Health Impacts from Routine Releases of VOCs

Site	Lifetime Cancer Risk	Major Contributor (percent of total)	Maximum HI	VOC with Maximum HI
WIPP				
Noninvolved Worker	1E-7	1,1,2,2-tetrachloroethane (86)	6E-4	Carbon tetrachloride
70-year MEI	5E-8	1,1,2,2-tetrachloroethane (94)	7E-5	Carbon tetrachloride
50-mile Population	2E-5	1,1,2,2-tetrachloroethane (89)	N/A	N/A
WHB Worker	2E-4	1,2-dichloroethane (30)	2	Carbon tetrachloride
Underground Worker	9E-4	1,1,2,2-tetrachloroethane (86)	6	Carbon tetrachloride
Lag storage - Hanford East & West				
Noninvolved Worker	2E-7	1,1,2,2-tetrachloroethane (92)	5E-4	Carbon tetrachloride
70-year MEI	1E-7	1,1,2,2-tetrachloroethane (95)	6E-4	Carbon tetrachloride
50-mile Population	3E-4	1,1,2,2-tetrachloroethane (91)	N/A	N/A
Lag storage - INEL				
Noninvolved Worker	5E-7	1,1,2,2-tetrachloroethane (84)	4E-3	Carbon tetrachloride
70-year MEI	4E-8	1,1,2,2-tetrachloroethane (90)	3E-5	Carbon tetrachloride
50-mile Population	1E-4	1,1,2,2-tetrachloroethane (80)	N/A	N/A
Lag storage - LANL				
Noninvolved Worker	4E-8	1,1,2,2-tetrachloroethane (64)	7E-4	Carbon tetrachloride
70-year MEI	1E-7	1,1,2,2-tetrachloroethane (79)	6E-4	Carbon tetrachloride
50-mile Population	3E-4	1,1,2,2-tetrachloroethane (66)	N/A	N/A
Lag storage - RFETS				
Noninvolved Worker	1E-8	1,1,2,2-tetrachloroethane (72)	2E-4	Carbon tetrachloride
70-year MEI	2E-8	1,1,2,2-tetrachloroethane (88)	6E-5	Carbon tetrachloride
50-mile Population	1E-3	1,1,2,2-tetrachloroethane (65)	N/A	N/A
Lag storage - ORNL				
Noninvolved Worker	3E-8	1,1,2,2-tetrachloroethane (96)	3E-5	Carbon tetrachloride
70-year MEI	1E-7	1,1,2,2-tetrachloroethane (99+)	3E-5	Carbon tetrachloride
50-mile Population	6E-4	1,1,2,2-tetrachloroethane (95)	N/A	N/A
Lag storage - SRS				
Noninvolved Worker	1E-7	1,1,2,2-tetrachloroethane (92)	2E-4	Carbon tetrachloride
70-year MEI	3E-8	1,1,2,2-tetrachloroethane (96)	2E-5	Carbon tetrachloride
50-mile Population	5E-4	1,1,2,2-tetrachloroethane (93)	N/A	N/A

N/A = Not Applicable

The impacts to the noninvolved worker, MEI, and populations at WIPP and the lag storage sites are presented in Table F-26. The maximum HIs for the noninvolved worker and the MEI would be 7×10^{-3} (noninvolved worker at Hanford) and 9×10^{-4} (MEI at LANL) for carbon tetrachloride. Therefore, no noncarcinogenic effects would be expected from routine stack releases under Action Alternative 3. The Action Alternative 3 WHB worker and underground worker have HIs greater than one for carbon tetrachloride (2 [WHB] and 10 [underground]). Air concentrations for involved workers would be at least two orders of magnitude below the PEL. Individual probabilities of cancer incidence of 4×10^{-7} (noninvolved worker at Hanford) and 2×10^{-7} (MEI at LANL) were estimated from exposure to routine releases of VOCs. This would be the lifetime carcinogenic risk for the 35 years (noninvolved worker) and 70 years (MEI) that the individual was conservatively assumed to be exposed. No cancers would occur in the 80-kilometer (50-mile) population (maximum expected number of cancers over each 35-year period would be 1×10^{-3} for RFETS).

Table F-26
Action Alternative 3 Impacts from Routine Releases of VOCs

Site	Lifetime Cancer Risk	Major Contributor (percent of total)	Maximum HI	VOC with Maximum HI
WIPP				
Noninvolved Worker	5E-8	1,1,2,2-tetrachloroethane (62)	1E-3	Carbon tetrachloride
70-year MEI	2E-8	1,1,2,2-tetrachloroethane (77)	1E-4	Carbon tetrachloride
50-mile Population	1E-5	1,1,2,2-tetrachloroethane (60)	N/A	N/A
WHB Worker	6E-5	Carbon tetrachloride (72)	2	Carbon tetrachloride
Underground Worker	5E-4	1,1,2,2-tetrachloroethane (60)	10	Carbon tetrachloride
Lag storage - Hanford East & West				
Noninvolved Worker	4E-7	1,1,2,2-tetrachloroethane (63)	7E-3	Carbon tetrachloride
70-year MEI	2E-7	1,1,2,2-tetrachloroethane (76)	7E-4	Carbon tetrachloride
50-mile Population	6E-4	1,1,2,2-tetrachloroethane (58)	N/A	N/A
Lag storage - INEL				
Noninvolved Worker	2E-7	1,1,2,2-tetrachloroethane (67)	4E-3	Carbon tetrachloride
70-year MEI	3E-8	1,1,2,2-tetrachloroethane (83)	9E-5	Carbon tetrachloride
50-mile Population	6E-5	1,1,2,2-tetrachloroethane (59)	N/A	N/A
Lag storage - LANL				
Noninvolved Worker	5E-8	1,1,2,2-tetrachloroethane (63)	9E-4	Carbon tetrachloride
70-year MEI	2E-7	1,1,2,2-tetrachloroethane (81)	9E-4	Carbon tetrachloride
50-mile Population	4E-4	1,1,2,2-tetrachloroethane (60)	N/A	N/A
Lag storage - RFETS				
Noninvolved Worker	1E-8	1,1,2,2-tetrachloroethane (63)	2E-4	Carbon tetrachloride
70-year MEI	2E-8	1,1,2,2-tetrachloroethane (81)	7E-5	Carbon tetrachloride
50-mile Population	1E-3	1,1,2,2-tetrachloroethane (62)	N/A	N/A
Lag storage - ORNL				
Noninvolved Worker	5E-9	1,1,2,2-tetrachloroethane (70)	8E-5	Carbon tetrachloride
70-year MEI	2E-8	1,1,2,2-tetrachloroethane (81)	1E-4	Carbon tetrachloride
50-mile Population	1E-4	1,1,2,2-tetrachloroethane (59)	N/A	N/A
Lag storage - SRS				
Noninvolved Worker	5E-8	1,1,2,2-tetrachloroethane (76)	6E-4	Carbon tetrachloride
70-year MEI	1E-8	1,1,2,2-tetrachloroethane (76)	6E-5	Carbon tetrachloride
50-mile Population	2E-4	1,1,2,2-tetrachloroethane (58)	N/A	N/A

N/A = Not Applicable

F.3.2.5 No Action Alternative 1

No routine releases of VOCs would occur because VOCs in the waste would be destroyed during thermal treatment to meet the LDRs.

F.3.2.6 No Action Alternative 2

No Action Alternative 2 considers treating newly generated, Basic Inventory TRU waste to meet WAC. To estimate impacts due to chronic exposure to VOCs, it was assumed that the total number of drum-equivalents of waste for each major storage site would be present in the facility at the beginning of the operations period. All exposed individuals were assumed to be exposed for the entire 35-year operating period.

Impacts to the noninvolved worker, MEI, and populations are presented in Table F-27. The maximum HI would be 1×10^{-3} (noninvolved worker at INEL) and 4×10^{-4} (MEI at LANL), for carbon tetrachloride. No noncarcinogenic effects would be expected for routine releases for No Action Alternative 2. An individual probability of cancer incidence of 2×10^{-7} (noninvolved worker at INEL) and 4×10^{-8} (MEI at LANL) would result from the routine releases of VOCs.

Table F-27
No Action Alternative 2 Impacts from Routine Releases of VOCs

Site	Lifetime Cancer Risk	Major Contributor (percent of total)	Maximum HI	VOC with Maximum HI
Hanford East & West				
Noninvolved Worker	1E-7	1,1,2,2-tetrachloroethane (92)	3E-4	Carbon tetrachloride
35-year MEI	3E-8	1,1,2,2-tetrachloroethane (83)	3E-5	Carbon tetrachloride
50-mile Population	4E-4	1,1,2,2-tetrachloroethane (94)	N/A	N/A
INEL				
Noninvolved Worker	2E-7	1,1,2,2-tetrachloroethane (81)	1E-3	Carbon tetrachloride
35-year MEI	5E-9	1,1,2,2-tetrachloroethane (64)	1E-5	Carbon tetrachloride
50-mile Population	5E-5	1,1,2,2-tetrachloroethane (83)	N/A	N/A
LANL				
Noninvolved Worker	2E-8	1,1,2,2-tetrachloroethane (64)	4E-4	Carbon tetrachloride
35-year MEI	4E-8	1,1,2,2-tetrachloroethane (80)	4E-4	Carbon tetrachloride
50-mile Population	2E-4	1,1,2,2-tetrachloroethane (65)	N/A	N/A
RFETS				
Noninvolved Worker	7E-9	1,1,2,2-tetrachloroethane (70)	1E-4	Carbon tetrachloride
35-year MEI	5E-9	1,1,2,2-tetrachloroethane (85)	4E-5	Carbon tetrachloride
50-mile Population	7E-4	1,1,2,2-tetrachloroethane (65)	N/A	N/A
ORNL				
Noninvolved Worker	1E-8	1,1,2,2-tetrachloroethane (92)	1E-5	Carbon tetrachloride
35-year MEI	3E-8	1,1,2,2-tetrachloroethane (97+)	2E-5	Carbon tetrachloride
50-mile Population	3E-4	1,1,2,2-tetrachloroethane (93)	N/A	N/A
SRS				
Noninvolved Worker	9E-8	1,1,2,2-tetrachloroethane (97)	1E-4	Carbon tetrachloride
35-year MEI	1E-8	1,1,2,2-tetrachloroethane (92)	1E-5	Carbon tetrachloride
50-mile Population	4E-4	1,1,2,2-tetrachloroethane (92)	N/A	N/A

N/A = Not Applicable

The annual risk would be equivalent to 1/35th of the total value. No cancers are expected in the 80-kilometer (50-mile) population (maximum number of cancers would be 7 x 10^{-4} for RFETS).

VOCs would presumably be emitted from the storage area stack after the waste disposition operations end. Impacts to the population and noninvolved worker would be no greater than that estimated during the operations period. Conservatively assuming constant emission rates, the maximum impact to an MEI exposed for 70 years would be twice that of the 35-year carcinogenic impact to the MEI (see Table F-27) for the operations period. The HI for the 70-year MEI would not be any greater than that of the 35-year MEI exposed during the operations period, because HIs are determined on an annual basis.

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APPENDIX G

APPENDIX G
FACILITY ACCIDENTS

This appendix describes the methods used to estimate the health impacts that may result from exposure to radioactive materials and hazardous chemicals from postulated facility accident scenarios during (1) treatment at various U.S. Department of Energy (DOE or the Department) facilities, (2) storage of treated waste at these facilities, and (3) disposal of treated waste at the Waste Isolation Pilot Plant (WIPP). The health impacts analyzed include the carcinogenic and noncarcinogenic effects that may result from the release of radionuclides, volatile organic compounds (VOC), and hazardous metals.

The potential impacts of an accident depend on both the type of treatment and the treated waste form, which vary by alternative. Waste could be minimally treated to meet the requirements of the planning-basis Waste Acceptance Criteria (WAC) (as under the Proposed Action, Action Alternative 1, and No Action Alternative 2), thermally treated to meet the Resource Conservation and Recovery Act (RCRA) land disposal restrictions (LDR) (as under all of the Action Alternative 2 subalternatives and No Action Alternative 1 subalternatives), or treated by a shred and grout process (as under Action Alternative 3). Descriptions of the waste treatment methods are included in Chapter 2. Generalized characteristics of the final waste forms from each treatment method are as follows:

- *Waste treated to planning-basis WAC* contains a variety of combustible and noncombustible transuranic (TRU) waste materials in various unconsolidated and consolidated forms.

- *Waste treated thermally* is immobilized in a glass-like, noncombustible, uniformly mixed mass and contains no VOCs, which are removed during the treatment process.

- *Waste treated by a shred and grout process* solidifies liquid waste and small pieces of solid TRU waste into a uniform, concrete-like matrix. For the purposes of analysis, it was assumed that this waste would contain the same headspace volume and concentration of VOCs as waste treated to planning-basis WAC.

G.1 TECHNICAL APPROACH

The following sections describe the technical approach used to calculate potential impacts to human health from exposure to radionuclides and hazardous chemicals.

G.1.1 Radionuclide Impacts

The health impacts from acute exposures to radionuclides from accidental releases were calculated as described in Appendix F. Total effective dose equivalents (TEDE) were calculated and converted to estimates of latent cancer fatalities (LCF) using dose conversion factors recommended by the International Commission on Radiological Protection (ICRP) and endorsed by the National Council on Radiation Protection and Measurements (NCRP) and federal regulatory bodies. For populations, the number of estimated LCFs are reported. For individuals the estimated probability (or percent chance, which is the probability multiplied by 100) of an LCF occurring is reported for the maximally exposed individual (MEI), the maximally exposed involved worker (worker who

would directly handle waste), and the maximally exposed noninvolved worker (worker who would not directly handle waste).

The nominal values of lifetime cancer risk for low dose or low-dose rate exposure used in this supplemental environmental impact statement (SEIS-II) are 5×10^{-4} per rem for a population of all ages and 4×10^{-4} per rem for a working population. These values are based on recommendations of the ICRP (ICRP 1991) and endorsed by the NCRP (NCRP 1993). The ICRP concluded that it would be appropriate to use a nominal value of 1×10^{-3} per rem effective dose for the lifetime risk of fatal cancer for a population of all ages and a nominal value of 8×10^{-4} per rem for a working population for high dose or high-dose rate exposure (ICRP 1991). The ICRP also recommended a Dose and Dose-Rate Effectiveness Factor (DDREF) of two to convert risk estimates after high dose and high-dose rate exposure to those expected after low dose or low-dose rate exposure. For the purposes of estimating radiological impacts from acute exposures due to accidental releases, analyses in SEIS-II do not include the DDREF if the annual effective dose equivalent in any year is greater than 20 rem. This assumption is applied to dose equivalents from low and high linear energy transfer (LET) radiation and may result in overestimating the number of LCFs from a given radiation dose by a factor of two.

Exposure Pathway, Radionuclide, and Waste-Type Screening

Impacts from accidents are caused mainly by inhalation intakes during the period of plume passage. Impacts from the external dose pathway were also considered but were determined to be several orders of magnitude less than inhalation impacts; therefore, they are not included in the impacts reported here. The ingestion pathway was not considered in the accident analyses because, in the event of an accident, it was assumed that DOE would take action to mitigate potential impacts from ingestion of crops and animal products raised within the area potentially affected by accident releases. Were they to be considered, radiological impacts from the ingestion pathway would only account for 10 percent of the contact-handled (CH) TRU waste impacts from inhalation and about 15 to 30 percent of the remote-handled (RH) TRU waste impacts from inhalation.

The radionuclides most likely to pose the greatest overall risk in the event of a treatment accident were identified by screening. Screening calculations for the inhalation pathway were determined in a manner similar to that of the external dose pathway in Appendix F. Radionuclide-specific inhalation dose factors (DF) were multiplied by the waste volumes and the radionuclide and hazardous chemical inventories (1995 activity) at each major waste consolidation site to create an inhalation screening value. Inhalation DFs were obtained from DOE (1988). Six TRU radionuclides – plutonium-238 (Pu-238), plutonium-239 (Pu-239), plutonium-240 (Pu-240), plutonium-241 (Pu-241), and americium-241 (Am-241) were found to be the largest dose contributors via the inhalation pathway. The plutonium-239 equivalent curies (PE-Ci) limits in the planning-basis WAC were used as a bounding waste radionuclide inventory for evaluating radiological impacts from waste storage and WIPP disposal operations and accidents.

The number of accident scenarios that potentially involve RH-TRU waste container breaches are limited. The main difference between the RH-TRU waste and CH-TRU waste is the presence of larger amounts of fission and activation products (e.g., cesium-137 [Cs-137]/barium-137m [Ba-137m] and cobalt-60 [Co-60]) in RH-TRU waste. These fission and activation products emit penetrating X- and gamma radiation and are more likely to enter human food chains. However, RH-TRU waste containers are constructed to prevent breaching in the event of a severe impact

accidents and, therefore, would be expected to release only small amounts of particulates. Also, RH-TRU waste packages would be doubly contained in drums and waste canisters.

The average PE-Ci levels of RH-TRU waste are typically less than those of CH-TRU waste. As a result, the radiological impacts of a CH-TRU waste accidents will be greater than (and, therefore, will bound) RH-TRU waste accidents.

G.1.2 Hazardous Chemical Impacts

The following sections describe how carcinogenic and noncarcinogenic impacts from VOCs and hazardous metals were calculated.

G.1.2.1 Carcinogenic Impacts from Hazardous Chemicals

Carcinogenic impacts from hazardous chemicals are presented as the number of cancers that may occur in an exposed population and as the probability of a cancer occurring in a MEI. Slope factors have been developed by the U.S. Environmental Protection Agency (EPA) to assist in estimating the potential for cancer incidence from a lifetime (estimated to be 70 years) of exposure to a specific hazardous chemical (EPA 1996). Table G-1 presents the slope factors for hazardous metals included in SEIS-II. Only cadmium and beryllium were included in SEIS-II analyses for carcinogenic impacts, because slope factors are not available for lead and mercury. Slope factors for VOCs analyzed in SEIS-II are found in Appendix F.

No standard method exists to calculate the carcinogenic risk from an acute (one-time or short-term) intake. SEIS-II analyses used the chronic-exposure slope factors and assumed the total acute intake was averaged over the 70-year lifetime. In practice, then, slope factors were used but specified as the risk per total acute intake.

Table G-1
Carcinogenic Risk Factors for Hazardous Metals

Hazardous Chemical	Inhalation Slope Factor [risk per milligram per kilogram per day][a]	Comment
Cadmium	6.3	Probable human carcinogen. SEIS-II assumes the ingestion slope factor equals the inhalation slope factor.
Beryllium	8.4	Probable human carcinogen.
Lead	not available	Probable human carcinogen. Age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of lead. As a result, development of carcinogenic risk factors using standard methods was not believed to be appropriate.
Mercury	not available	Classification as a carcinogen is not possible due to poor database of carcinogenic effects upon which to base a determination.

[a] Inhalation slope factor from IRIS converted risk per microgram per cubic meter to risk per milligram per kilogram per day by assuming a 20 cubic meter per day inhalation rate and an individual body mass of 70 kilograms (EPA 1996).

G.1.2.2 Noncarcinogenic Impacts from Hazardous Chemicals

Two methods were used to estimate the noncarcinogenic impacts from postulated facility accidents. The first method was to compare the intake estimate to the "equivalent intakes" of the National Institute for Occupation Safety and Health (NIOSH) immediate-dangerous-to-life-and-health (IDLH) values (NIOSH 1996). The IDLH values, originally developed by NIOSH for emergency response purposes, are air concentrations based on a 30-minute exposure period in which an individual is assumed to inhale 10 cubic meters (353 cubic feet) of contaminated air. The IDLH-equivalent intake level is the quantity of material inhaled during the 30 minutes of exposure at the IDLH concentration. The exposure time of the individuals in the SEIS-II accident scenarios is much shorter than 30 minutes, given the assumptions that involved workers would immediately exit the accident site and that the air concentration is the result of a 1-second release. As a result of the short exposure time, the IDLH-equivalent intake was used as the impact measure reference value rather than the IDLH concentration. IDLH and IDLH-equivalent intake values are presented in Table G-2.

Table G-2
IDLH Values for Facility Accident Noncarcinogenic Impact Analysis

Hazardous Chemical[a]	Immediately Dangerous to Life and Health (IDLH) Values[b]	IDLH-Equivalent Intake Values (milligrams)
Benzene (3.25)	500 ppm	16,250
Carbon Tetrachloride (6.39)	200 ppm	12,780
Chlorobenzene (4.68)	1,000 ppm	46,800
Chloroform (4.96)	500 ppm	24,800
1,1-Dichloroethylene (4.03)	Not Determined	----
1,2-Dichloroethane (4.11)	50 ppm	2,060
Ethyl Benzene (4.41)	800 ppm	35,280
Methyl Ethyl Ketone (3.0)	3,000 ppm	90,000
Methylene Chloride (3.53)	2,300 ppm	81,190
1,1,2,2-Tetrachloroethane (7.0)	100 ppm	7,000
Tetrachloroethene (6.89)	150 ppm	10,335
Toluene (3.83)	500 ppm	19,150
Xylene (4.41)	900 ppm	39,690
Beryllium	4 milligrams/cubic meter	40
Cadmium	9 milligrams/cubic meter	90
Lead	100 milligrams/cubic meter	1,000
Mercury	10 milligrams/cubic meter	100

[a] Values in parentheses for VOCs are milligrams per cubic meter per ppm conversion factors for the calculation of the IDLH-equivalent intake.
[b] NIOSH 1996.

The second method of evaluating noncarcinogenic accident impacts was to calculate and compare the air concentrations to which workers would be exposed to Emergency Response Planning Guidelines (ERPG) developed by the American Industrial Hygiene Association (AIHA). The ERPGs are air concentrations that may be tolerated by an individual for a 60-minute period, defined for three levels of health impacts:

- The ERPG-1 air concentration is the "low" health impact level and is defined as the maximum air concentration below which it is believed that nearly all individuals could be

exposed for up to one hour without experiencing anything other than mild transient adverse health effects or without perceiving a clearly defined objectionable odor.

- ERPG-2 air concentrations are slightly more hazardous. The ERPG-2 level is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

- ERPG-3 air concentrations indicate a high impact from the exposure. The EPRG-3 level is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening effects. Above ERPG-3 values, an individual may experience or develop a life-threatening effect as a result of a 1-hour exposure.

Analyses using ERPGs are useful in determining if individuals could encounter levels of VOCs that could potentially lead to transient or serious health effects.

The difficulty with using the ERPG approach to evaluate potential impacts from accidental releases is that values have not been defined for all of the hazardous chemicals evaluated in SEIS-II. When no AIHA ERPG value was available, a substitute value was used (Craig et al. 1994). These substitute methods use resources such as time-weighted average (TWA) concentrations and short-term exposure limits (STEL) from the American Conference of Government Industrial Hygienists (ACGIH) and IDLHs from NIOSH. Table G-3 presents the ERPG values used in SEIS-II; where no AIHA value was available, the substitute method used is indicated.

Table G-3
ERPG Values for Facility Accident Noncarcinogenic Impact Analysis

Chemical Name	ERPG-1 (milligrams/ cubic meter)	ERPG-2 (milligrams/ cubic meter)	ERPG-3 (milligrams/ cubic meter)	Reference
Carbon tetrachloride	130	640	4800	HEHF 1995
Chloroform	500	5000	25,000	HEHF 1995
1,1-dichloroethylene	60 [a]	100 [c]	---	ACGIH 1995
1,2-dichloroethane	120 [a]	200 [c]	200 [d]	ACGIH/NIOSH 1995
Methylene chloride	---	1400	3500	HEHF 1995
Chlorobenzene	140 [a]	230 [c]	4700 [d]	ACGIH/NIOSH 1995
Methyl ethyl ketone	885 [b]	3000 [c]	9000 [d]	ACGIH/NIOSH 1995
1,1,2,2-tetrachloroethane	21 [a]	35 [c]	700 [d]	ACGIH/NIOSH 1995
Toluene	580	770	7700	Craig et al. 1994
Benzene	80	800	3300	HEHF 1995
Ethyl benzene	543 [b]	2200 [c]	3500 [d]	ACGIH/NIOSH 1995
Tetrachloroethene	690	1380	3500	Craig et al. 1994
Xylene	660	880	4400	Craig et al. 1994
Beryllium	0.006[a]	0.025	0.1	HEHF 1995
Cadmium	0.2	1	10	HEHF 1995
Lead	0.15[a]	0.25[c]	100[d]	ACGIH/NIOSH 1995
Mercury	0.075	0.1	28	Craig et al. 1994

Footnotes indicate the method of calculation of a substitute value: [a] TWA x 3; [b] STEL; [c] TWA x 5; [d] IDLH

The ERPG values were compared to the air concentrations to which an individual would be acutely exposed for the accident scenarios evaluated under treatment, storage, or disposal operations. If the ratio of the air concentration to the ERPG was greater than 1, an adverse impact would be expected.

G.1.2.3 Volatile Organic Compound Screening

The 13 VOCs that may be found in TRU waste (see Tables F-1 or F-2 in Appendix F) were screened to determine which were major contributors to carcinogenic and noncarcinogenic impacts. To develop a VOC screening value, VOC impact measures were compared to the VOC container headspace concentration. For example, screening values for carcinogenic impact were determined by multiplying the VOC slope factor by the headspace concentration, while two noncarcinogenic impact screening values were determined by dividing the headspace concentration by the IDLH-equivalent intake and the ERPG-2 values. Those VOCs with the greatest individual impact contribution were included for more detailed accident impact analyses, with an estimated summed impact of at least 90 percent of the overall VOC impact. The VOCs included in the SEIS-II accident analyses are presented in sections G.2 (Treatment Accident Scenarios) and G.3 (Storage Accident Scenarios). All 13 VOCs were evaluated for the WIPP disposal accident scenarios (Section G.4).

G.1.3 Selection of Accident Scenarios

Three scenarios were selected for analysis of treatment and storage accidents: one high-frequency/low-consequence accident, one low-frequency/high-consequence accident, and one natural disaster. These scenarios were selected to offer a wide span of possible accidents, while allowing comparability between alternatives. Though the scenarios change among alternatives, each includes a waste spill, a waste fire or explosion, and an earthquake that would collapse the storage or treatment building. An earthquake was selected as the beyond-design-basis accident for analysis (rather than a plane crash or tornado, for instance) but the risk would be comparable to other beyond-design-basis accidents. The estimated accident frequencies among alternatives and sites were assumed to be identical except for some storage and WIPP disposal accidents involving thermally treated waste, which were lower because of the final waste form. Seismic design guidelines for DOE facilities are based on facility usage categories. For each category, an earthquake hazard level is specified using site-specific seismic hazard data. This process ensures that facilities are designed on a uniform basis for the effects of seismic events, regardless of their locations. A beyond-design-basis earthquake, regardless of accident frequency, must be assumed to defeat all building confinement functions. Buildings are typically constructed to withstand earthquakes. Therefore, the frequency of the beyond-design-basis earthquake scenario was leveled across the country by the assumption that the building would collapse.

Only three scenarios are presented for treatment and storage accidents, because no actual facility design or specific facility location has been selected or would be selected as a result of this supplemental environmental impact statement. Additional site-specific National Environmental Policy Act (NEPA) reviews and safety analyses would be conducted before operations of such facilities would be begun.

At WIPP, no future NEPA reviews are planned before a decision is made on whether to begin disposal operations. For that reason, eight accident scenarios were assessed for WIPP disposal

accidents. These accidents include both CH-TRU and RH-TRU waste accidents in the Waste Handling Building and underground.

G.2 TREATMENT ACCIDENT SCENARIOS

This section presents the evaluation of the potential impacts of treatment facility accidents for each of three types of treatment: treatment to planning-basis WAC (under the Proposed Action, Action Alternative 1, and No Action Alternative 2); thermal treatment (under the Action Alternative 2 subalternatives and No Action Alternative 1 subalternatives); and treatment by a shred and grout process (under Action Alternative 3). Accident scenarios were evaluated for each of the treatment alternatives at the major treatment sites – Hanford Site (Hanford), Idaho National Engineering Laboratory (INEL), Los Alamos National Laboratories (LANL), Rocky Flats Environmental Technology Site (RFETS), Oak Ridge National Laboratory (ORNL), Savannah River Site (SRS), and, for Action Alternative 2C only, WIPP.

Treatment accident analysis results are presented only for accident scenarios involving CH-TRU waste because CH-TRU waste has a greater potential for radiological impacts (i.e., CH-TRU waste has greater concentrations of the TRU radionuclides that are the most significant contributors to radiation dose). For this reason, for the treatment accident analysis only, CH-TRU waste was assumed to be present at each site regardless of where it would actually be treated.

Because no VOC sampling has been conducted for RH-TRU waste, CH-TRU waste and RH-TRU waste VOC headspace concentrations were assumed to be the same. Estimated hazardous metal concentrations presented in Appendix A are also the same for all metals except lead, where RH-TRU waste quantities were estimated to be about 100 times those of CH-TRU waste quantities. Hazardous metal impacts, however, were estimated to be quite low in all cases, even under conservative accident assumptions. (RH-TRU waste hazardous metal impacts could be higher than CH-TRU waste hazardous metal impacts as a result of the lead content of RH-TRU waste. It is likely, though, that they would be less than the factor of 100 difference in lead content.)

G.2.1 Inventory

The inventory of materials to be treated that could potentially cause human health impacts includes both radionuclides and hazardous chemicals. Hazardous chemicals that may be present in TRU waste include VOCs and hazardous metals. Appendix A presents the description of the radionuclide and hazardous chemical inventories in greater detail.

G.2.1.1 Radionuclide Inventory

In order to provide a reasonable upper limit on the TRU waste radionuclide inventory, the radionuclide content of each drum was assumed to be ten times the overall average concentration of that radionuclide at all DOE sites. Nine radionuclides were determined to be the principal contributors to dose in the treatment accident scenarios. These nine radionuclides together would contribute more than 90 percent of the impact due to such accidents.

Because all nine radionuclides may not be present at each site, each was screened to determine its contribution to the impacts. For the radionuclides evaluated, the "ten-times average" concentration was used at each site (see Table G-4).

Table G-4
Radionuclide Activity per Drum for Treatment Accident Analyses[a, b]

Radionuclide	Sites Where Radionuclide is a Major Dose Contributor[c]	CH-TRU Waste (Ci/drum)[d]	RH-TRU Waste (Ci/drum)	CH-TRU/RH-TRU Waste Activity Ratio
Pu-238	H, I, L, O, S, W	27.7	0.11	260
Pu-239	H, I, L, R, S, W	11.2	0.35	32
Pu-240	H, R, O	2.2	0.12	18
Pu-241	O	46.2	3.0	16
Am-241	H, I, L, R, O, S, W	7.5	0.3	25
Np-239	O	6.9E-04	-----	-----
Bi-214	O	2.5E-04	-----	-----
Co-60	I	2.0E-03	0.6	3E-3
Ba-137m	H, L	0.025	11.2	2E-3

[a] Maximum estimated drum activities are ten times the average drum activity of all sites.
[b] Analyses were based on 1995 stored volumes and IDB radionuclide inventories (DOE 1994b), also cited in Appendix A.
[c] H = Hanford, I = INEL, L = LANL, R = RFETS, O = ORNL, S = SRS, W = WIPP. Waste treated at ORNL is all RH-TRU waste.
[d] Includes plutonium residue radionuclide inventories.

G.2.1.2 Hazardous Chemical Inventory

Hazardous chemicals that may be present in TRU waste are VOCs and hazardous metals. Six VOCs and four metals were evaluated for potential human health impacts from treatment facility accidents.

Volatile Organic Compounds

VOCs were assumed to be present in all TRU waste entering the treatment facilities; therefore, screening calculations (see Section G.1.2.3) were used to determine those VOCs with the greatest potential impact for treatment facility accidents (see Table G-5). VOC headspace concentration estimates were made using INEL and RFETS sampling data from CH-TRU waste and applied to the various waste matrix categories at the different sites (Appendix A). The average concentration across all sites was then calculated and multiplied by 10 to account for the presence of maximum concentrations in individual drums. VOCs were assumed to be present in all waste treated to planning-basis WAC and the shred and grout process; no VOCs, however, would be present in waste after thermal treatment (Action Alternative 2). The presence of a maximum concentration of a specific VOC has no bearing on whether another VOC will be found in the same container at a high concentration. The VOC headspace concentrations assumed to be present for treatment accident analyses are presented in Table G-5.

Table G-5
VOC Headspace Concentrations for Treatment Accident Analyses[a]

VOC	Headspace Concentration (ppmv)
Carbon tetrachloride	1,849
Methylene chloride	6,621
1,1,2,2-tetrachloroethane	3,357
Benzene	76
Tetrachloroethene	71
Xylene	256

[a] VOC concentrations are ten times the overall average VOC concentrations of all sites.

Hazardous Metals

The inventory of metals in TRU waste was derived from estimates developed for the WIPP Safety Analysis Report (SAR) (DOE 1995b). The SAR assumed a conservatively high concentration of metals in its analysis of a waste fire, and the waste forms used were the result of treatment to planning-basis WAC. These values were used as the basis for estimating the hazardous metal inventories from thermally treated waste and waste that had been treated by the shred and grout process (see Appendix A.5.1). Inventories of hazardous metals that were assumed to be uniformly mixed in each drum of TRU waste are presented in Table G-6.

Table G-6
Hazardous Metal Concentrations in TRU Waste for Treatment Accident Analyses[a]

Hazardous Metals	CH-TRU Waste (kilograms/drum)	RH-TRU Waste (kilograms/drum)[a]
Lead	1.0	97
Beryllium	0.025	0.025
Cadmium	4E-4	4E-4
Mercury	0.43	0.43

[a] Based on information presented in Table A-41. One drum-equivalent contains 0.208 cubic meters of waste.

G.2.2 Treatment Accident Analysis

Three accident scenarios were analyzed for each of the three treatment methods: two operational accidents and one natural disaster accident. Operational accidents were chosen to include a high-frequency/low-consequence scenario and a low-frequency/high-consequence scenario. The estimated annual frequencies of occurrence for treatment accidents were taken from source documents and are presented in Table G-7. When a frequency range was identified, the highest value (i.e., the greater probability) was used in the analysis.

Table G-7
Annual Frequencies of Occurrence for Treatment Accidents

SEIS-II Accident Scenario	Accident Description	Estimated Frequency
Waste Treated to Planning-Basis WAC		
T1	Waste Spill	1E-2
T2	Drum Fire	1E-4
T3	Earthquake	1E-5 or less
Waste Thermally Treated		
T4	Drum Failure	1E-2
T5	Steam Explosion	1E-4
T6	Earthquake	1E-5 or less
Waste Treated by Shred and Grout		
T7	Waste Spill	1E-2
T8	Fire in Shredder	1E-4
T9	Earthquake	1E-5 or less

Criticality concerns were not addressed by a formal analysis, because of the low concentration of radionuclides within these waste materials and the almost complete absence of fissionable isotopes of these radionuclides. A criticality event would require the possibility of a chain reaction for neutron generation, which can only occur if fissionable material in a critical geometry becomes available. With the waste materials at hand, there is not enough fissionable material in existence to achieve a critical configuration. The criticality question has been previously addressed (DOE 1987) in the context of an environmental impact statement discussing disposal of high level wastes, TRU wastes, and tank wastes at Hanford. It was concluded that there is no credible basis for a criticality potential. Earlier evaluations (Wallace et al. 1980) have come to the same conclusion.

G.2.2.1 Accidents During Treatment to Planning-Basis WAC

Treatment of TRU waste to planning-basis WAC is the treatment option for the Department's Proposed Action, Action Alternative 1, and the newly generated waste in No Action Alternative 2. Treatment to planning-basis WAC, under each of these alternatives, would be conducted at the site where the waste is currently stored or would be generated. Each site was assumed to have its own on-site waste treatment facility.

Treatment to planning-basis WAC may include some or all of the following waste management unit operations: receiving; monitoring and sampling waste for radioactive and hazardous chemicals; opening of drums or boxes; transfer of contents to a conveyor belt for sorting; cutting large objects to fit the shredder; shredding; transfer of contents to a conveyor belt for sorting; assaying; filling a drum; closing of a drum with a vented lid; labeling; frisking; and certifying that applicable packaging and transportation criteria have been met. Subsequently, the treated and repackaged material would be consolidated at the 10 largest generator-storage sites to await shipment to WIPP, or, in the case of No Action Alternative 2, would remain in storage at the 10 largest generator-storage sites.

As stated above, larger nonmetallic objects might be shredded during the treatment process so that a reduced volume could be stored in a drum. Thus, if shredding is performed, the sorting area might receive two feed streams: one directly from the drum emptying station and the other from the shredder. The sorting process would probably include coarse separation of metals from nonmetals. Nonmetallic materials might be compressed in the final package drum while metallic parts, if not decontaminated and recycled as scrap, might be packaged without further volume reduction. The facility would probably use gloveboxes with HEPA (high efficiency particulate air) filters around the drum opening station, the conveyor belt, the shredder, and the sorting area. Although numerous options for treatment processes exist (DOE 1995a), no decision on the process has been made.

Accident Scenario T1 - Waste Spill

A waste spill is an anticipated event during the lifetime of the waste treatment facility, with an estimated annual occurrence frequency of about 0.01. In this accident scenario, a drum about to be filled with TRU waste would be mispositioned, resulting in a spill of dry, sorted waste materials from the conveyor belt onto the operating floor. The spill volume was assumed to be an entire drum volume (DOE 1990).

The airborne fraction of solids was estimated at 1×10^{-3}, with a respirable fraction of 0.1. The respirable fraction would be carried into the ventilation system, for which a filter transmission factor of 1×10^{-3} was assumed.

VOCs and other gaseous components previously attached to the material would have largely outgassed into the gloveboxes during the sorting process; still, a gaseous release fraction of 1.0 was assumed. All VOCs were assumed to be respirable and to completely pass through the HEPA filters.

The involved workers, positioned outside of the glovebox, were assumed to exit the facility immediately and thus would escape impact.

Accident Scenario T2 - Waste Drum Fire

A waste drum fire is not an anticipated event during the lifetime of any of the waste treatment facilities, with an estimated annual occurrence frequency of about 1×10^{-4}. In this accident scenario, a waste drum was postulated to spontaneously erupt into flames as it was opened but before it was emptied onto the conveyor belt for sorting.

It was postulated that 10 percent of the contents of the waste container would be combustible because all sites have average waste combustibles fractions ranging from 4 to 12 percent. Half of the combustible material would become airborne as respirable particles. The particles released would be subject to a high amount of deposition due to the heated aerosol reacting with the relatively cool surfaces within the treatment facility. Sixty percent of the release was assumed to plateout onto interior building surfaces, leaving 40 percent (0.4) available for release to the ventilation system. A filter transmission factor of 1×10^{-3} was assumed. All VOCs were assumed to be consumed by the fire.

The involved workers, positioned outside of the glovebox, were assumed to exit the facility immediately and thus would escape impact.

Accident Scenario T3 - Earthquake

An earthquake was postulated to be a beyond-design-basis natural event, with an estimated annual frequency of 1×10^{-5} or less. In this accident scenario, an earthquake would cause the collapse of the waste treatment facility and the loss of electrical power.

The total material at risk for this accident scenario was the contents of five drums (the assumed process inventory). Although some of the volatile gaseous components would have outgassed into the gloveboxes as the material moved through the treatment process facility, an in-facility release fraction of 1.0 was assumed for the volatile components. The solids fraction of the entire in-process inventory becoming airborne was estimated at 1×10^{-3}, of which the respirable fraction is assumed to be 0.1. A building removal factor of 0.5 was assumed, so that releases from the collapsed facility to the environment would be 0.5 of the airborne portion, based on the above described total in-process inventory.

During the events of this scenario, some involved workers would probably be killed during the collapse of the building. For the purposes of this analysis, though, some involved workers, were assumed to escape. These involved workers were assumed to inhale about 5.6 liters (1.5 gallons)

of contaminated air or about four average breaths at 1.25 liters (0.3 gallons) per breath for an average male during light activity (ICRP 1991).

A summary of the parameter values for the three accident scenarios during treatment to planning-basis WAC is shown in Table G-8.

Table G-8
Accident Analysis Parameters for Waste Treatment to Planning-Basis WAC for the Proposed Action, Action Alternative 1, and No Action Alternative 2

SEIS-II Accident Scenario	Accident Description	Number of Drums (N)	Release Fraction (f_{rel})	Respirable Fraction (f_{resp})	Filter Transmission Factor (f_{HEPA})	Other Removal Factors (R)
T1	Waste Spill	1	0.001 VOCs: 1.0	0.1 VOCs:1.0	0.001 VOCs: 1.0	N/A
T2	Waste Drum Fire	1	0.1 VOCs: 0	0.5	0.001	0.4
T3	Earthquake	5	0.001 VOCs: 1.0	0.1 VOCs:1.0	N/A	0.5 VOCs: 1.0

N/A = Not Applicable

G.2.2.2 Accidents During Thermal Treatment

This treatment option applies to all of the subalternatives of Action Alternative 2 and both of the subalternatives of No Action Alternative 1, in which all CH-TRU and RH-TRU waste materials would be thermally treated to meet the LDRs.

The process temperature for thermal treatment would probably range from 2,000 to 3,000 degrees Celsius. At these temperatures, all organic constituents would be disassembled and reoxidized, and thereby converted into mineral (nonorganic) substances. Depending on how much glass frit is added to this process, the resulting material might be predominantly glass or predominantly metal slag. If the glass configuration is selected, contiguous glass logs containing 25 percent by mass of waste oxides (Mishima et al. 1986) can be produced by pouring the melt directly into cylindrical carbon steel canisters, typically of 0.61-meter (2.0 feet) diameter and 3-meter (9.8 feet) length. A comprehensive compilation of the different vitrification processes (DOE 1995a) has been published, including: vitrification with combustion melting; continuous vitrification; vitrification with electric arc melting; vitrification with electric resistance melter; vitrification with fossil fuel fired melting, induction melting, joule heated melting, or microwave melting; plasma arc furnace; and others.

As the feed stream enters the glass pool, evaporation renders the feed materials dry. In a calcining phase, all organic materials decompose to form oxides and enter the glass pool. The relatively cool blanket of freshly formed oxides and unreacted materials that cover the melt is expected to condense most of the escaping volatile radionuclides and refluxes them to the melt. The resulting gaseous effluent will contain all of the remaining moisture, oxides of nitrogen (NO_X), carbon dioxide (CO_2), and some of the oxides of sulfur (SO_X) in the melter feed and, during infrequent periods of abnormal blanket distribution, up to 5 percent of the cesium (Mishima et al. 1986).

The thermal treatment option involves the following waste management unit operations: cutting larger objects to fit the shredder; shredding, if required; mixing the glass frit into the feed stream; routing the feed stream into the glass melter; pouring the final glass melt into the log forms; letting the logs cool to ambient temperature; packaging; labeling; frisking; and certifying that applicable packaging and transportation criteria are being met. Subsequently, the treated materials would remain at the treatment sites to await shipment to WIPP or, in the case of No Action Alternative 1, would remain indefinitely stored at the treatment sites.

Accident Scenario T4 - Waste Drum Failure

A waste drum failure is an anticipated event during the lifetime of the thermal treatment facility, with an estimated annual occurrence frequency of about 0.01. In this accident scenario, a waste drum would be breached (i.e., accidentally dropped in handling operations) before encapsulation (DOE 1982). For the purposes of this analysis, it was assumed that the rupture would be the equivalent to a cover block drop on an encapsulated drum.

In a scenario developed by Mishima et al. (1986) that has been evaluated previously (DOE 1982), a batch of thermally treated waste was assumed to be placed in five drums simultaneously and, through operator error, the drums would be ruptured by a concussive impact. A relatively small fraction of the glass would shatter during such an event, and it was assumed that a mass fraction of approximately 1×10^{-6} of the fragmented glass would be respirable and carried into the ventilation system (Mishima et al. 1986). A filter factor of 1×10^{-3} was assumed for the ventilation system. No VOCs were assumed to be released in this scenario because they would have been consumed in the thermal treatment process.

The involved workers, positioned outside of the glovebox, were assumed to exit the facility immediately and thus would escape impact.

Accident Scenario T5 - Steam Explosion in Glass Melter

A steam explosion in a glass melter is not an anticipated event during the lifetime of the waste treatment facility, with an estimated annual occurrence frequency of about 1×10^{-4}. In this accident scenario, failure of a cooling system or human error would cause water to become entrapped in a space where molten glass is poured, resulting in a steam explosion. Thus, placing liquid water in contact with molten glass causes flashing of trapped water into vapor. This phenomenon might occur in the melter or when the glass melt is poured into the log form.

In a scenario developed by Mishima et al. (1986) that has been evaluated previously (DOE 1982), a steam explosion was postulated to occur in the glass melter that was assumed to contain about 1,000 liters (5.6 drum equivalents) of molten product. The shock of the explosion would fragment the molten glass into a large number of small particles which would scatter throughout the operating area. It was assumed that a mass fraction of approximately 1×10^{-4} of the fragmented glass would be respirable and carried into the ventilation system, for which a filter factor of 1×10^{-3} was assumed. Volatilization of 80 percent of the mercury and 10 percent of the lead was postulated for the molten material involved in the explosion. All VOCs were assumed to be consumed in the melting process.

Because of the serious nature of the accident, the involved workers were assumed to be fatally injured. No other type of impacts were calculated for involved workers.

Accident Scenario T6 - Earthquake

An earthquake was postulated to be a beyond-design-basis natural event, with an estimated annual frequency of 1 x10^{-5} or less. In this accident scenario, an earthquake causes the collapse of the waste treatment facility and the loss of electrical power. The total material at risk was postulated to be the contents of 125 drums, which constitutes the assumed process inventory. Although some of the volatile gaseous components would have outgassed into the gloveboxes as the material moved through the treatment process facility, an in-facility release fraction of 1.0 was assumed for the volatile components in 63 of the 125 drums assumed to be in the facility awaiting treatment. The airborne solids fraction of the entire in-process inventory was estimated to be 1 x 10^{-3}, of which the respirable fraction was assumed to be 0.1. A building removal factor of 0.5 was assumed, so that releases from the collapsed facility to the environment would be 0.5 of the airborne portion, based on the above described total in-process inventory.

During the events of this scenario, involved workers would probably be killed by falling debris as the building collapses. For the purpose of this analysis it was assumed that some involved workers may exit the facility with the average worker in the immediate vicinity of the accident assumed to inhale about 5.6 liters (1.5 gallons) of contaminated air. This corresponds to about four average breaths, at 1.25 liters (0.3 gallons) per breath for an average male during light activity (ICRP 1991).

A summary of the parameter values for the three accident scenarios during thermal treatment is shown in Table G-9.

Table G-9
Accident Analysis Parameters for Thermal Treatment of Waste for the Action Alternative 2 and No Action Alternative 1 Subalternatives

SEIS-II Accident Scenario	Accident Description	Number of Drums (N)	Release Fraction (f_{rel})	Respirable Fraction (f_{resp})	Filter Transmission Factor (f_{HEPA})	Other Removal Factors (R)
T4	Waste Drum Failure	4.9	1E-6 VOCs: 0	1.0	0.001	N/A
T5	Steam Explosion in Glass Melter	5.6	0.001 VOCs: 0	0.1	0.001	Lead: 0.1 Mercury: 0.8
T6	Earthquake	125 VOCs: 63[a]	0.001 VOCs: 1.0	0.1 VOCs: 1.0	N/A	0.5 VOCs: 1.0

[a] Half of the drums at risk were assumed to be unprocessed and awaiting treatment (still containing VOCs).

N/A = Not Applicable

G.2.2.3 Accidents During Shred and Grout Treatment

This treatment option requires shredding of the waste materials into relatively uniform small pieces, (about 4 centimeters [1.6 inches]) to ensure a reasonable measure of structural integrity of the grout blocks. Any particulates and free liquids in the waste material are immobilized in this process, and any pyrophoric or corrosive characteristics of the TRU waste are eliminated. Compared to the treatment to planning-basis WAC option, the shred and grout process offers the advantage of

immobilizing the waste materials and significantly reducing the gas generation rate (as does the thermal treatment process) but without having to apply the energy intensive vitrification process. However, the disadvantage of this option is that the waste volume is significantly increased by adding the grout.

DOE has not yet selected a specific shred and grout process for TRU waste treatment. It is expected that a site-specific NEPA review will be performed for each site if this process is selected. The accident analyses assumed that the process design is comparable to the commercially available technology which has been successfully demonstrated at Hanford.

Accident Scenario T7 - Waste Spill

A waste spill is an anticipated event during the lifetime of the waste treatment facility, with an estimated annual occurrence frequency of about 0.01. In this accident scenario, a malfunction of the automatic equipment causes a drum about to be filled to be mispositioned, resulting in a spill of wet grouted waste materials onto the operating floor. An entire drum volume of waste was assumed to spill on the floor but, because of the nature of the grouted waste, only 25 percent of that waste would be available for further release (DOE 1990).

For VOCs and other gaseous components, a gaseous release fraction of 1.0 was postulated. The fraction of solids becoming airborne in this scenario was estimated at 1×10^{-3}, with a respirable fraction of 0.1. The respirable fraction would be carried into the ventilation system, for which a filter factor of 1×10^{-3} was assumed.

The involved workers, positioned outside of the glovebox, were assumed to exit the facility immediately and thus would escape impact.

Accident Scenario T8 - Fire in the Shredder

In this accident scenario, a fire would be initiated by either an explosion of fine particulates generated by the shredding process, or a spontaneous combustion of occluded pyrophoric material exposed to air by the shredder action. Because sparks generated during shredding of metal would be anticipated to cause small fires in the shredder, a fire suppression system was assumed to be in place. Failure of the fire suppression system and subsequent fire involving all of the contents in the shredder was estimated to be an extremely unlikely event, with an estimated annual occurrence frequency of about 1×10^{-4}.

It was postulated that 16 drums of material would be in the shredder or in the hopper and that the fire would spread to include all 16 drums and their contents. Ten percent of the contents of the waste container were assumed to be combustible because all sites have average waste combustibles fractions ranging from 4 to 12 percent. Half of the combustible material would be of respirable particle size. The particles released would be subject to a high amount of deposition due to the heated aerosol reacting with the relatively cool surfaces within the treatment facility. Sixty percent of the release was assumed to plateout onto interior building surfaces, leaving 40 percent (0.4) available for release to the ventilation system. A filter transmission factor of 1×10^{-3} was assumed. All VOCs were assumed to be consumed by the fire.

The involved workers, positioned outside of the glovebox, were assumed to exit the facility immediately and thus would escape impact.

Accident Scenario T9 - Earthquake

An earthquake was postulated to be a beyond design-basis-natural event, with an estimated annual frequency of 1 x 10^{-5} or less. In this accident scenario, an earthquake would cause the collapse of the waste treatment facility and the loss of electrical power. The total material at risk for this accident scenario would be the contents of 65 drums, which constitutes the assumed process inventory. Although some of the volatile gaseous components would have outgassed into the gloveboxes as the material moves through the treatment process facility, an in-facility release fraction of 1.0 was assumed for the volatile components. In addition, the solids fraction of the entire in-process inventory becoming airborne was estimated at 1 x 10^{-3}, of which the respirable fraction was assumed to be 0.1. A building removal factor of 0.5 was assumed, so that releases from the collapsed facility to the environment would be 0.5 of the airborne portion, based on the above described total in-process inventory.

During the events of this scenario, it would be expected that some involved workers would be killed by falling debris. For the purpose of this analysis, though, it was assumed some involved workers may exit the facility with the average worker in the immediate vicinity of the accident assumed to inhale about 5.6 liters (1.5 gallons) of contaminated air. This corresponds to about four average breaths, at 1.25 liters (0.3 gallons) per breath for an average male during light activity (ICRP 1991).

A summary of the parameter values for the three accident scenarios during shred and grout treatment is shown in Table G-10.

Table G-10
Accident Analysis Parameters for Shred and Grout Treatment of Waste for Action Alternative 3

SEIS-II Accident Scenario	Accident Description	Number of Drums (N)	Release Fraction (f_{rel})	Respirable Fraction (f_{resp})	Filter Transmission Factor (f_{HEPA})	Other Removal Factors (R)
T7	Waste Spill	1	0.001 VOCs: 1.0	0.1 VOCs: 1.0	0.001 VOCs: 1.0	0.25 [a]
T8	Fire in the Shredder	16	0.1 VOCs: 0	0.5	0.001	0.4
T9	Earthquake	65	0.001 VOCs: 1.0	0.1 VOCs: 1.0	N/A	0.5 VOCs: 1.0

[a] Fraction of contents that is released from drum.

N/A = Not Applicable

G.2.2.4 Source Term Analysis

The radionuclide and hazardous chemical source terms were estimated based on the Equation G-1 shown below:

$$S = (N)(Q)(R)(f_{rel})(f_{resp})(f_{HEPA}) \qquad \text{(Equation G-1)}$$

where

S = source term (Curies [Ci] or kilograms)

N = number of containers involved

Q = radionuclide or hazardous metal inventory of a waste container (from Appendix A)

R = factors accounting for other removal mechanisms, such as fraction of drum(s) at risk, volatilization of metals, and material remaining in the transport pathway after plateout of materials on facility surfaces

f_{rel} = fraction of the contents released from the container(s)

f_{resp} = fraction of the spilled or resuspended contents that are respirable-sized particles

f_{HEPA} = fraction of material that passes through the treatment facility HEPA filters and is released to the environment

The number of waste drums or containers at risk during an accident (N) is specific to each scenario and is easily determined for the higher frequency accidents. In most cases, N equals 1 drum. Special consideration was given to the earthquake analyses because of the catastrophic nature of the disaster and the potentially large inventories at risk. It was necessary to find the alternative-specific site that would process the maximum inventory over the course of the 35-year treatment period. In all cases but Action Alternative 2C, the site with the maximum inventory would be Hanford. In Action Alternative 2C, WIPP would have the highest processing inventory. This inventory was then analyzed on a daily basis over the course of 35 years with assumed operational efficiencies of 75 percent for treatment to planning-basis WAC, 60 percent for thermal treatment, and 50 percent for the shred and grout process. It was then postulated that workers could on average open five drums an hour and add them to the treatment batches. From these assumptions, it could be determined that thermal treatment would require the most number of process lines and treatment to planning-basis WAC would require the least. Assuming further that there were two batches treated each day for thermal and shred and grout treatments, continuous treatment to planning-basis WAC, and an earthquake that would only put one batch at a time at risk, it was possible to determine the number of drums in each earthquake scenario.

G.2.3 Exposure Analysis

As noted earlier, the potential inhalation doses would be much greater than the potential external doses, so only the doses from inhalation are presented here. Radiation doses were estimated at each site for radionuclides determined to be important dose contributors. Potential radiation doses to receptors were calculated using Equation G-2, then converted to the estimated number of LCFs in exposed populations or the estimated probability of an LCF for an individual.

$$\text{Dose}_{inh} = \sum_i (DCF_i \times S_i) \times \frac{E}{Q} \times 20 \times 1.0 \times 10^6 \times \frac{1}{86{,}400} \qquad \text{(Equation G-2)}$$

where

Dose_{inh} = total inhalation dose to a receptor from all radionuclides (rem)

DCF_i = inhalation dose conversion factor for radionuclide i (rem/year per microcurie [μCi] inhaled)

S_i = source term of radionuclide i released to the environment (Ci)

E/Q = time integrated concentration at a point downwind where the receptor is located (seconds/cubic meter)

20 = breathing rate (cubic meters/day)

1.0×10^6 = conversion factor (μCi/Ci).

1/86,400 = conversion factor (day/second).

Dose conversion factors were taken from DOE/EH-0071 (DOE 1988) for internal dose rates. Where there was a choice, as in the case of inhalation DCFs, the highest value was used in the analysis.

E/Q values were calculated using the GENII computer code (Napier et al. 1988) to the nearest public access point for the MEI, to the maximum population-weighted sector for populations, and to the point of highest concentration for the noninvolved worker. The noninvolved worker population was assumed to be the entire site population exposed at the same concentration as the noninvolved worker. The impacts to exposed populations are presented in Table G-11, and the impacts to the MEIs and noninvolved workers are presented in Table G-12. Release heights from all facilities were assumed to be 10 meters (33 feet) from the ground surface. It was further assumed that the location of the facility did not depend on the treatment technology.

Table G-11
Exposed Population Locations, Sizes, and Atmospheric Dispersion Factors for Treatment and Storage Accident Analysis

Site	Population Sector	Population-Weighted E/Q (seconds/cubic meter)	80-kilometer (50-mile) Sector Population
Hanford	SE	1.1	98,865
INEL	E	0.055	75,162
LANL	ENE	0.48	10,381
RFETS	SE	2.2	180,867
ORNL	E	1.6	214,419
SRS	WNW or NW	0.16	194,597 (WNW), 111,899 (NW)
WIPP	W	0.061	25,629

Table G-12
MEI and Noninvolved Worker Locations and Atmospheric Dispersion Factors for Treatment and Storage Accident Analysis

Site	MEI Location	E/Q (seconds/cubic meter)	Noninvolved Worker Location	E/Q (seconds/cubic meter)
Hanford	4,200 meters WSW	2.8E-4	100 meters S	1.8E-3
INEL	4,000 meters ENE	2.3E-5	100 meters S	4.0E-4
LANL	500 meters NNE	6.5E-4	100 meters W	1.4E-3
RFETS	2,600 meters NNW	1.3E-4	300 meters N	6.4E-4
ORNL	720 meters NNW	1.2E-3	100 meters SW	1.4E-3
SRS	12,000 meters NNW	8.9E-6	100 meters WSW	8.7E-4
WIPP	300 meters S	6.5E-4	300 meters S	6.5E-4

The source term was determined as discussed in Sections G.2.1.1 and G.2.2.

Exposure to hazardous chemicals and metals were evaluated on both a carcinogenic and noncarcinogenic basis. The total risk summed over all carcinogens was analyzed for both chemicals and metals across populations or individuals. For noncarcinogenic impacts, the intake of a specific hazardous chemical was compared to the IDLH-equivalent intake and the ERPG-2 value.

For hazardous chemicals, both VOCs and hazardous metals impacts were evaluated using Equation G-3 below for carcinogens and Equations G-4 and G-5 for noncarcinogens.

$$\text{CarcRisk} = \frac{E}{Q} \times S \times \text{SlopFctr} \times 20 \times \frac{1}{86{,}400} \times \frac{1}{(70 \times 70 \times 365.25)} \qquad \text{(Equation G-3)}$$

where

CarcRisk	=	Risk of contracting cancer due to exposure to carcinogenic materials
S	=	Source term or the total release of hazardous chemical (milligrams)
SlopFctr	=	Carcinogenic slope factor or the cancer risk per unit intake (kilograms-day/milligrams)
20	=	breathing rate (cubic meters/day)
1/86,400	=	conversion factor (day/second)
70	=	mass of reference adult (kilograms)
70	=	lifespan of reference individual (years)
365.25	=	(days/year)

$$IDLHF = \frac{\left(\frac{E}{Q} \times S \times 20 \times \frac{1}{86{,}400}\right)}{IDLH_{eq}} \qquad \text{(Equation G-4)}$$

where

IDLHF = the comparison of a worker's intake to the level at which a hazardous material is immediately dangerous to life or health if exposed for 30 minutes

IDLHeq = the equivalent amount that a worker would inhale if exposed for the entire 30-minute period at the IDLH level

20 = breathing rate (cubic meters/day)

1/86,400 = conversion factor (days/second)

$$ERPGF = \frac{\left(\frac{E}{Q} \times S\right)}{ERPG\text{-}X} \qquad \text{(Equation G-5)}$$

where

ERPGF = comparison of the air concentration at the worker's location to the level at which emergency response protection guides take effect

ERPG-X = the emergency response protection guide levels where X = 1, 2, or 3, and

where

ERPG-1 = the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or without perceiving a clearly defined objectionable odor

ERPG-2 = the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action

ERPG-3 = the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects

Evaluation of the noncarcinogenic chemical impacts results in a value that is compared to 1.0. If the impact value is less than 1.0, then a noncarcinogenic impact is unlikely to occur. If the value is greater than 1.0, then a noncarcinogenic impact may occur and additional investigation or mitigation measures may be necessary.

G.2.4 Impacts of Treatment Accidents

Impacts from treatment accidents were calculated for the exposed off-site population, the MEI, and the maximally exposed noninvolved worker for each of the potentially affected sites (Hanford, INEL, LANL, RFETS, ORNL, SRS, and, for Action Alternative 2C only, WIPP). Impacts to the maximally exposed involved worker were addressed qualitatively. As noted earlier, inhalation would be the dominant exposure pathway and was considered for impacts from exposure to radionuclides, VOCs, and hazardous metals. Acute releases were assumed to be dispersed in one direction, so population impacts were estimated for a single, maximally exposed, 22.5-degree sector (out to 80 kilometers [50 miles]) and not for the entire 80-kilometer (50-mile) region population. Population-weighted atmospheric dispersion values were calculated and used to determine the maximally-impacted sector, considering both the change in air concentration over distance and the population distribution in the sector.

Radiological impacts would be greater than impacts from VOCs or hazardous metals for all types of treatment evaluated, due to increased potential for radiation-related LCFs. No cancer incidence would be expected from exposure to hazardous chemicals under any of the alternatives. Some life-threatening toxicological effects could occur to MEIs during the postulated earthquake events.

G.2.4.1 Treatment Accident Impacts for the Proposed Action, Action Alternative 1, and No Action Alternative 2

The impacts from treatment accidents for waste treated to meet the planning-basis WAC are shown in Tables G-13 to G-15 and are discussed below for the population, MEI, noninvolved worker, and involved worker. These accident analyses apply to the Proposed Action, Action Alternative 1, and No Action Alternative 2. Radiological impacts from accidents during treatment to planning-basis WAC would be lower than impacts from the other two scenarios. Potential impacts from hazardous chemicals, both carcinogenic and noncarcinogenic, are low in all cases.

Impacts to Population

The potential radiological impacts to the populations surrounding any site are greatest for ORNL (see Table G-13). This is due to a combination of the radionuclides determined to be significant at the ORNL site through screening calculations and the population-weighted dispersion factor for the population east of ORNL. No cancer fatalities would be expected from the operational accident scenarios T1 or T2 (a waste spill or waste drum fire during treatment to planning-basis WAC) at ORNL or any other site. Accident Scenario T1 population impacts would range from 1×10^{-5} to 4×10^{-4} LCFs, and Accident Scenario T2 population impacts would range from 3×10^{-3} to 0.02 LCFs. For Accident Scenario T3 (an earthquake during treatment to planning-basis WAC), impacts would range from 0.04 to 1.0 LCFs, with ORNL having the greatest number of LCFs.

Table G-13
Radiological Impacts from Treatment Accidents for Waste Treated to the Planning-Basis WAC

Sites	Accident Scenario T1 (Waste Spill)		Accident Scenario T2 (Drum Fire)		Accident Scenario T3 (Earthquake)	
Population	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
Hanford	0.6	3E-4	120	0.06	1,500	0.8
INEL	0.03	1E-5	6	3E-3	70	0.04
LANL	0.2	1E-4	50	0.02	620	0.3
RFETS	0.5	3E-4	110	0.05	1,400	0.7
ORNL	0.9	4E-4	180	0.09	2,200	1.0
SRS	0.06	3E-5	10	6E-3	150	0.8
MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
Hanford	2E-4	8E-8	0.03	2E-5	0.4	2E-4
INEL	1E-5	6E-9	2E-3	1E-6	0.03	1E-5
LANL	3E-4	2E-7	0.07	3E-5	0.8	4E-4
RFETS	3E-5	2E-8	6E-3	3E-6	0.08	4E-5
ORNL	7E-4	3E-7	0.1	7E-5	2.0	8E-4
SRS	3E-6	2E-9	7E-4	3E-7	9E-3	4E-6
Maximally Exposed Noninvolved Worker						
Hanford	1E-3	5E-7	0.2	9E-5	3.0	1E-3
INEL	2E-4	1E-7	0.05	2E-5	0.6	2E-4
LANL	9E-4	3E-7	0.2	7E-5	2.0	9E-4
RFETS	2E-4	8E-8	0.04	2E-5	0.5	2E-4
ORNL	9E-4	4E-7	0.2	7E-5	2.0	9E-4
SRS	4E-4	2E-7	0.08	3E-5	1.0	4E-4
Maximally Exposed Involved Worker						
Any Site	0	0	0	0	600	0.2

The potential hazardous chemical impacts to the population are very small. No cancer fatalities are expected in the populations surrounding the six major sites as a result of the hazardous chemical or metal releases from any analyzed accident scenario. Impacts range from 2×10^{-13} to 2×10^{-7} cancers for Accident Scenario T1, 3×10^{-11} to 1×10^{-9} cancers for Accident Scenario T2, and 4×10^{-10} to 1×10^{-6} cancers for Accident Scenario T3 (see Table G-14).

Impacts to Maximally Exposed Individual

The potential radiological impacts to the MEI are greatest for ORNL for all three accidents scenarios analyzed for treatment to planning-basis WAC (see Table G-13). The magnitude of the impacts is due to a combination of the radionuclides determined to be significant at the ORNL site through the screening calculations discussed above and to the MEI air dispersion factor. In Accident Scenario T1 (waste spill), radiation doses to the MEI would range from 3×10^{-6} to 7×10^{-4} rem TEDE, with an associated probability of an LCF of 2×10^{-9} to 3×10^{-7}. In Accident Scenario T2 (waste drum fire), radiation doses to the MEI would range from 7×10^{-4} to 0.1 rem TEDE, with an associated probability of an LCF of 3×10^{-7} to 7×10^{-5}. In Accident Scenario T3 (earthquake), radiation doses to the MEI would range from 9×10^{-3} to 2 rem TEDE, with an associated probability of an LCF of 4×10^{-6} to 8×10^{-4}.

Table G-14
Hazardous Chemical Carcinogenic Impacts from Treatment Accidents for Waste Treated to the Planning-Basis WAC

Sites	Accident Scenario T1 (Waste Spill)		Accident Scenario T2 (Drum Fire)		Accident Scenario T3 (Earthquake)	
	VOCs	Metals	VOCs	Metals	VOCs	Metals
Population	**Number of Cancers**		**Number of Cancers**		**Number of Cancers**	
Hanford	1E-7	3E-12	0	6E-10	6E-7	8E-9
INEL	6E-9	2E-13	0	3E-11	3E-8	4E-10
LANL	5E-8	1E-12	0	3E-10	2E-7	3E-9
RFETS	2E-7	6E-12	0	1E-9	1E-6	2E-8
ORNL	2E-7	4E-12	0	9E-10	8E-7	1E-8
SRS	2E-8	4E-13	0	9E-11	8E-8	1E-9
MEI	**Probability of Cancer**		**Probability of Cancer**		**Probability of Cancer**	
Hanford	3E-11	8E-16	0	2E-13	1E-10	2E-12
INEL	2E-12	6E-17	0	1E-14	1E-11	2E-13
LANL	7E-11	2E-15	0	4E-13	3E-10	4E-12
RFETS	1E-11	4E-16	0	7E-14	7E-11	9E-13
ORNL	1E-10	3E-15	0	7E-13	6E-10	8E-12
SRS	9E-13	2E-17	0	5E-15	5E-12	6E-14
Maximally Exposed Noninvolved Worker						
Hanford	2E-10	7E-15	0	1E-12	9E-10	2E-11
INEL	4E-11	2E-15	0	3E-13	2E-10	4E-12
LANL	1E-10	6E-15	0	1E-12	7E-10	1E-11
RFETS	7E-11	3E-15	0	5E-13	3E-10	6E-12
ORNL	1E-10	6E-15	0	1E-12	7E-10	1E-11
SRS	9E-11	3E-15	0	7E-13	5E-10	9E-12
Maximally Exposed Involved Worker						
Any Site	0	0	0	0	2E-7	3E-6

The potential hazardous chemical impacts are greatest at ORNL for all three accident scenarios, because the MEI air dispersion factor is greater at ORNL than at any of the other sites and because the inventories of hazardous chemicals and metals are assumed to be the same at all of the sites. Overall, however, the carcinogenic impacts from the accidents are very small. Carcinogenic impacts are no greater than a 1×10^{-10}, 7×10^{-13}, and 6×10^{-10} probability of contracting cancer for Accident Scenarios T1, T2, and T3, respectively (see Table G-14). Noncarcinogenic impacts ratios of 1.0 or greater would indicate the potential for a noncarcinogenic impact. For Accident Scenario T3, the maximum ERPG-2 ratio is equal to 1.0 at ORNL for both mercury and lead (see Table G-15). Therefore, some irreversible impacts would be expected, but no life-threatening effects would be expected (the ERPG-3 ratio is 6×10^{-3}). The maximum IDLH-equivalent ratio for Accident Scenario T3 is 3×10^{-7} for the ORNL MEI. For Accident Scenario T1, the maximum ERPG-2 ratio for the MEI is 0.1 and the maximum IDLH-equivalent ratio is 1×10^{-7}. Finally, for Accident Scenario T2, the maximum ERPG-2 ratio is 0.1 and the IDLH-equivalent ratio is 2×10^{-8}. Therefore, the only serious impacts would be expected under the beyond-design-basis accident involving the earthquake.

Table G-15
Hazardous Chemical Noncarcinogenic Impacts from Treatment Accidents for Waste Treated to the Planning-Basis WAC

	Accident Scenario T1 (Waste Spill)				Accident Scenario T2 (Drum Fire)				Accident Scenario T3 (Earthquake)			
	VOCs		Metals		VOCs		Metals		VOCs		Metals	
Site	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]
MEI												
Hanford	3E-8	0.03	3E-11	1E-4	0	0	6E-9	0.02	2E-7	0.1	7E-8	0.3
INEL	3E-9	2E-3	2E-12	1E-5	0	0	5E-10	2E-3	1E-8	0.01	6E-9	0.02
LANL	7E-8	0.06	6E-11	3E-4	0	0	1E-8	0.06	4E-7	0.3	2E-7	0.7
RFETS	1E-8	0.01	1E-11	6E-5	0	0	3E-9	0.01	7E-8	0.06	3E-8	0.1
ORNL	1E-7	0.1	1E-10	5E-4	0	0	2E-8	0.1	7E-7	0.6E-1	3E-7	1.0
SRS	1E-9	9E-4	9E-13	4E-6	0	0	2E-10	8E-4	5E-9	4E-3	2E-9	0.01
Maximally Exposed Noninvolved Worker												
Hanford	2E-7	0.2	3E-10	8E-4	0	0	5E-8	0.2	1E-6	0.9	6E-7	2.0
INEL	5E-8	0.04	6E-11	2E-4	0	0	1E-8	0.03	2E-7	0.2	1E-7	0.4
LANL	2E-7	0.1	2E-10	6E-4	0	0	4E-8	0.1	8E-7	0.7	5E-7	2.0
RFETS	7E-8	0.06	9E-11	3E-4	0	0	2E-8	0.06	4E-7	0.3	2E-7	0.7
ORNL	2E-7	0.1	2E-10	6E-4	0	0	4E-8	0.1	8E-7	0.7	5E-7	2.0
SRS	1E-7	0.09	1E-10	4E-4	0	0	2E-8	0.07	5E-7	0.4	3E-7	0.9
Maximally Exposed Involved Worker												
Any Site	0	0	0	0	0	0	0	0	2E-4	9	0.1	19

[a] The highest ratio of the receptor hazardous chemical intake to the IDLH-equivalent value.
[b] The highest ratio of the receptor hazardous chemical air concentration to the ERPG-2 value.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological impacts to the noninvolved worker are greatest for Hanford for all three accident scenarios analyzed (see Table G-13). The noninvolved worker impacts are driven by the site-specific dispersion factor for this individual and by the radionuclides with the greatest impact found to be at this site during the screening process. Under Accident Scenario T1 (waste spill), the radiation doses to the noninvolved worker would range from 2×10^{-4} to 1×10^{-3} rem TEDE, with an associated probability of an LCF of 8×10^{-8} to 5×10^{-7}. Under Accident Scenario T2 (waste drum fire), the radiation doses to the noninvolved worker would range from 0.04 to 0.2 rem TEDE, with an associated probability of an LCF of 2×10^{-5} to 9×10^{-5}. Under Accident Scenario T3 (earthquake), the radiation doses to the noninvolved worker would range from 0.5 to 3 rem TEDE to the noninvolved worker. The potential Accident Scenario T3 impacts to the LANL, ORNL, and Hanford noninvolved worker would be the most serious; the probability of an LCF for the individuals at these sites would range from 2×10^{-4} to 1×10^{-3}.

The potential hazardous chemical impacts to the noninvolved worker are greatest for the Hanford noninvolved worker for all accident scenarios evaluated (see Table G-14). However, the impacts are very small. Hazardous chemical carcinogenic impacts would be no greater than a 2×10^{-10}, 1×10^{-12}, and 9×10^{-10} probability of contracting cancer for Accident Scenarios T1, T2, and T3, respectively. Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for a noncarcinogenic impact. For Accident Scenario T3, the maximum ERPG-2 ratio is equal to 2 at Hanford, LANL, and ORNL for both mercury and lead. Therefore, some irreversible impacts would be expected, but no life-threatening effects would be expected (ERPG-3 ratios of 0.1, 0.09, and 0.04 at Hanford, LANL, and ORNL, respectively). The maximum IDLH-equivalent ratio for Accident Scenario T3 is 1×10^{-6} for the Hanford noninvolved worker. For both Accident Scenarios T1 and T2, the maximum ERPG-2 ratios for the noninvolved worker is 0.2 and the

maximum IDLH-equivalent ratio is 2×10^{-7}. Therefore, the only serious impacts would be expected under the beyond-design-basis accident involving an earthquake.

Impacts to Maximally Exposed Involved Worker

No radiological or chemical impacts to the maximally exposed involved worker would be anticipated from either the waste spill (Accident Scenario T1) or the drum fire (Accident Scenario T2). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the event. Substantial radiological and chemical impacts would be possible from a beyond-design-basis earthquake (Accident Scenario T3), ranging from workers killed by debris from the collapsing treatment facilities to high external radiation doses from RH-TRU waste treatment and intakes of radionuclides, VOCs, and hazardous metals. Intakes of radionuclides could result in a dose of up to 600 rem, with a corresponding probability of an LCF of 0.2 (see Table G-13). The probability of cancer from exposure to VOCs and hazardous metals would be 2×10^{-7} and 3×10^{-6}, respectively (see Table-14). Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for the noncarcinogenic impact. For VOCs, the maximum ERPG-2 ratio would be 9 and the maximum IDLH-equivalent ratio would be 2×10^{-4} (see Table G-15). For hazardous metals, the maximum ERPG-2 ratio would be 19 (and an ERPG-3 ratio of 1) and the maximum IDLH-equivalent ratio would be 0.1.

G.2.4.2 Treatment Accident Impacts for Action Alternative 2 and No Action Alternative 1

The impacts from thermal treatment accidents are shown in Tables G-16 to G-18 and are discussed below for the population, MEI, maximally exposed noninvolved worker, and maximally exposed involved worker. These accident analyses apply to all of the subalternatives of Action Alternative 2 and No Action Alternative 1. Radiological impacts from thermal treatment accidents are the highest of the three treatment methods examined. There would be no impacts from VOCs, because they are destroyed during the treatment process. Carcinogenic impacts from hazardous metals are low in all cases, but some life-threatening toxicological effects could occur to MEIs during the postulated earthquake events.

Impacts to Population

Under Action Alternatives 2A and 2B, the potential radiation impacts to the populations surrounding any site are greatest for ORNL (see Table G-16). This is due to a combination of the radionuclides determined to be significant at the ORNL site through screening calculations and to the population-weighted dispersion factor for the population east of ORNL. No cancer fatalities would be expected from the operational Accident Scenarios T4 or T5 (drum failure or steam explosion) at ORNL or any other facility. Accident Scenario T4 population impacts would range from 1×10^{-6} to 4×10^{-5} LCFs, and Accident Scenario T5 population impacts would range from 8×10^{-5} to 2×10^{-3} LCFs. For Accident Scenario T6 (earthquake during thermal treatment of waste), the impacts for all sites would range from 0.9 to 30 LCFs, with the greatest number of LCFs at ORNL.

Under Action Alternative 2C, where all of the CH-TRU waste would be treated at WIPP, the expected number of LCFs in the population for Accident Scenarios T4, T5, and T6 would be 1×10^{-6}, 9×10^{-5} and 1, respectively.

Table G-16
Radiological Impacts from Treatment Accidents for Thermally Treated Waste

Site	Accident Scenario T4 (Drum Failure)		Accident Scenario T5 (Steam Explosion)		Accident Scenario T6 (Earthquake)	
	Dose (person-rem)	Number of LCFs	Dose (person-rem)	Number of LCFs	Dose (person-rem)	Number of LCFs
Population						
Hanford	0.06	3E-5	3.0	2E-3	37,000	20
INEL	3E-3	1E-6	0.2	8E-5	1,800	0.9
LANL	0.02	1E-5	1.0	7E-4	16,000	8.0
RFETS	0.08	4E-5	3.0	2E-3	34,000	20
ORNL	0.08	4E-5	5.0	2E-3	55,000	30
SRS	7E-3	4E-6	0.3	2E-4	3,900	2.0
WIPP	3E-3	1E-6	0.2	9E-5	2,000	1.0
MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
Hanford	1E-5	7E-9	9E-4	4E-7	10	5E-3
INEL	1E-6	6E-10	7E-5	3E-8	0.7	4E-4
LANL	3E-5	2E-8	2E-3	1E-6	20	0.01
RFETS	5E-6	2E-9	2E-4	9E-8	2.0	1E-3
ORNL	6E-5	3E-8	4E-3	2E-6	40	0.02
SRS	4E-7	2E-10	2E-5	1E-8	0.2	1E-4
WIPP	4E-5	2E-8	3E-3	1E-6	30	0.01
Maximally Exposed Noninvolved Worker						
Hanford	1E-4	4E-8	7E-3	3E-6	70	0.03
INEL	2E-5	9E-9	1E-3	6E-7	20	6E-3
LANL	8E-5	3E-8	5E-3	2E-6	50	0.02
RFETS	2E-5	1E-8	1E-3	4E-7	10	5E-3
ORNL	8E-5	3E-8	5E-3	2E-6	60	0.02
SRS	4E-5	2E-8	2E-3	9E-7	30	0.01
WIPP	5E-5	2E-8	3E-3	1E-6	40	0.01
Maximally Exposed Involved Worker						
Any Site	0	0	0	0	14,800	1

The potential hazardous chemical and hazardous metal impacts to the population are very small; therefore, no cancers are expected in the populations surrounding the six major sites or at WIPP as a result of releases from any analyzed accident. Impacts would range from 7×10^{-15} to 3×10^{-13} cancers for Accident Scenario T4, 8×10^{-13} to 3×10^{-11} cancers for Accident Scenario T5, and 9×10^{-9} to 8×10^{-5} cancers for Accident Scenario T6. The WIPP site has the highest potential cancer incidence (8×10^{-5} risk) under Action Alternative 2C, while RFETS has the next highest (3×10^{-5} risk) for Action Alternatives 2A and 2B.

Impacts to Maximally Exposed Individual

Under Action Alternatives 2A and 2B, the potential radiological impacts to the MEI are greatest for ORNL (see Table G-16). This is a combination of the radionuclides determined to be significant at the ORNL site through screening calculations and the MEI air dispersion factor. In a waste drum failure (Accident Scenario T4), radiation doses to the MEI range from 4×10^{-7} to 6×10^{-5} rem TEDE, with an associated probability of an LCF of 2×10^{-10} to 3×10^{-8}. In a steam explosion (Accident Scenario T5), radiation doses to the MEI range from 2×10^{-5} to 4×10^{-3} rem TEDE, with an associated probability of an LCF of 1×10^{-8} to 2×10^{-6}. In an earthquake (Accident Scenario T6), radiation doses to the MEI range from 0.2 to 40 rem TEDE, with an associated probability of an LCF of 1×10^{-4} to 0.02.

Table G-17
Hazardous Chemical Carcinogenic Impacts from Treatment Accidents for Thermally Treated Waste

Site	Accident Scenario T4 (Drum Failure)		Accident Scenario T5 (Steam Explosion)		Accident Scenario T6 (Earthquake)	
	VOCs	Metals	VOCs	Metals	VOCs	Metals
Population	**Number of Cancers**		**Number of Cancers**		**Number of Cancers**	
Hanford	0	1E-13	0	2E-11	7E-6	2E-7
INEL	0	7E-15	0	8E-13	4E-7	9E-9
LANL	0	6E-14	0	7E-12	3E-6	8E-8
RFETS	0	3E-13	0	3E-11	1E-5	4E-7
ORNL	0	2E-13	0	2E-11	1E-5	3E-7
SRS	0	2E-14	0	2E-12	1E-6	3E-8
WIPP	0	8E-15	0	9E-13	4E-7	1E-8
MEI	**Cancer Incidence**		**Cancer Incidence**		**Cancer Incidence**	
Hanford	0	4E-17	0	4E-15	2E-9	5E-11
INEL	0	3E-18	0	4E-16	1E-10	4E-12
LANL	0	9E-17	0	1E-14	4E-9	1E-10
RFETS	0	2E-17	0	2E-15	8E-10	2E-11
ORNL	0	2E-16	0	2E-14	8E-9	2E-10
SRS	0	1E-18	0	1E-16	6E-11	2E-12
WIPP	0	1E-16	0	1E-14	4E-9	2E-10
Maximally Exposed Noninvolved Worker						
Hanford	0	3E-16	0	4E-14	1E-8	4E-10
INEL	0	8E-17	0	9E-15	3E-9	1E-10
LANL	0	3E-16	0	3E-14	9E-9	3E-10
RFETS	0	1E-16	0	1E-14	4E-9	2E-10
ORNL	0	3E-16	0	3E-14	9E-9	3E-10
SRS	0	2E-16	0	2E-14	6E-9	2E-10
WIPP	0	2E-16	0	2E-14	4E-9	2E-10
Maximally Exposed Involved Worker						
Any Site	0	0	0	0	3E-6	7E-5

WIPP is the only treatment site for the CH-TRU waste under Action Alternative 2C. In Accident Scenario T4, radiation dose to the WIPP MEI would be 4×10^{-5} rem TEDE, with an associated probability of an LCF of 2×10^{-8}. In Accident Scenario T5, radiation dose to the WIPP MEI would be 3×10^{-3} rem TEDE, with an associated probability of an LCF of 1×10^{-6}. In Accident Scenario T6, radiation dose to the WIPP MEI is 30 rem TEDE, with an associated probability of an LCF of 0.01.

Under Action Alternatives 2A and 2B, the potential hazardous chemical impacts are greatest at ORNL for Accident Scenarios T4, T5, and T6. This is because the MEI air dispersion factor is greater at ORNL than at any of the other sites and because the inventories of hazardous chemicals and metals are assumed to be the same at all the sites. Overall, however, the carcinogenic impacts from the accidents are very small. Carcinogenic impacts are no greater than a 2×10^{-16}, 2×10^{-14}, and 2×10^{-10} probability of contracting cancer for Accident Scenarios T4, T5, and T6, respectively (see Table G-17). Under Action Alternative 2C, all the impacts are to the WIPP MEI but are very low. The probability of contracting cancer from Accident Scenarios T4, T5, and T6 would be 1×10^{-16}, 1×10^{-14}, and 8×10^{-9}, respectively.

Table G-18
Hazardous Chemical Noncarcinogenic Impacts from Treatment Accidents for Thermally Treated Waste

	Accident Scenario T4 (Drum Failure)				Accident Scenario T5 (Steam Explosion)				Accident Scenario T6 (Earthquake)			
	VOCs		Metals		VOCs		Metals		VOCs		Metals	
Site	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]	IDLH[a]	ERPG-2[b]
MEI												
Hanford	0	0	1E-12	6E-6	0	0	1E-10	5E-4	2E-6	2	2E-6	8.0
INEL	0	0	1E-13	5E-7	0	0	1E-11	4E-5	2E-7	0.1	1E-7	0.6
LANL	0	0	3E-12	1E-5	0	0	3E-10	1E-3	5E-6	4	4E-6	20
RFETS	0	0	6E-13	3E-6	0	0	6E-11	3E-4	9E-7	0.8	8E-7	3.0
ORNL	0	0	6E-12	3E-5	0	0	5E-10	2E-3	8E-6	7	7E-6	30
SRS	0	0	4E-14	2E-7	0	0	4E-12	2E-5	8E-8	0.05	6E-8	0.2
WIPP	0	0	4E-12	2E-5	0	0	4E-10	2E-3	5E-6	4	5E-6	20
Maximally Exposed Noninvolved Worker												
Hanford	0	0	1E-11	4E-5	0	0	1E-9	3E-3	1E-5	10	2E-5	50
INEL	0	0	3E-12	8E-6	0	0	3E-10	8E-4	3E-6	2	4E-6	10
LANL	0	0	1E-11	3E-5	0	0	9E-10	3E-3	1E-5	9	1E-5	40
RFETS	0	0	4E-12	1E-5	0	0	4E-10	1E-3	5E-6	4	6E-6	20
ORNL	0	0	1E-11	3E-5	0	0	9E-10	3E-3	1E-5	9	1E-5	40
SRS	0	0	6E-12	2E-5	0	0	6E-10	2E-3	6E-6	5	8E-6	20
WIPP	0	0	6E-12	2E-5	0	0	6E-10	2E-3	5E-6	4	8E-6	20
Maximally Exposed Involved Worker												
Any Site			0	0	0	0	0	0	3E-3	110	3	475

[a] The highest ratio of the receptor hazardous chemical intake to the IDLH-equivalent value.
[b] The highest ratio of the receptor hazardous chemical air concentration to the ERPG-2 value.

Noncarcinogenic impacts ratios of 1.0 or greater would indicate the potential for a noncarcinogenic impact. For Accident Scenario T6 under both Action Alternatives 2A and 2B, the maximum ERPG-2 ratio equals 30 at ORNL for both mercury and lead and 8 for beryllium (see Table G-18). The maximum ERPG-3 ratio is 2 for beryllium, but less than 1 for mercury and lead; thus, these ratios indicate that life-threatening effects would be expected. The maximum IDLH-equivalent ratio for Accident Scenario T6 is 8×10^{-6} for the ORNL MEI. For Accident Scenario T4, the maximum ERPG-2 ratio for the MEI is 3×10^{-5} and the maximum IDLH-equivalent ratio is 6×10^{-12}, and for Accident Scenario T5, the maximum ERPG-2 ratio is 2×10^{-3} and the IDLH-equivalent ratio is 5×10^{-10}. Therefore, the only serious impacts would be expected under the beyond-design-basis accident. The same holds true for Action Alternative 2C where all the impacts would be at WIPP. For Accident Scenario T4, the maximum ERPG-2 ratio for the WIPP MEI is 2×10^{-5} and the maximum IDLH-equivalent ratio is 4×10^{-12}, and for Accident Scenario T5, the maximum ERPG-2 ratio is 2×10^{-3} and the IDLH-equivalent ratio is 4×10^{-10}. For Accident Scenario T6, the maximum ERPG-2 ratio is 20 for both mercury and lead and 6 for beryllium, while the maximum ERPG-3 ratio is 1 for beryllium and 0.08 and 0.05 for mercury and lead respectively. Thus, life-threatening effects would be expected to the MEI for Accident Scenario T6 at WIPP.

Impacts to Maximally Exposed Noninvolved Worker

Under Action Alternatives 2A and 2B, the potential radiological impacts to the noninvolved worker are greatest to Hanford for all accidents evaluated (see Table G-16). The noninvolved worker impacts are driven by the site-specific dispersion factor for this individual and by the site-specific mix of radionuclides chosen for the evaluation. Under Accident Scenario T4, the radiation doses to

the noninvolved worker range from 2×10^{-5} to 1×10^{-4} rem TEDE, with an associated probability of an LCF of 9×10^{-9} to 4×10^{-8}. Under Accident Scenario T5, the radiation doses to the noninvolved worker range from 1×10^{-3} to 7×10^{-3} rem TEDE, with an associated probability of an LCF of 6×10^{-7} to 3×10^{-6}. Under Accident Scenario T6, the radiation doses to the noninvolved worker range from 20 to 70 rem TEDE, with an associated probability of an LCF of 6×10^{-3} to 0.03.

Under Action Alternative 2C, all the impacts would be to the WIPP noninvolved worker. Under Accident Scenario T4, the radiation dose to the noninvolved worker is 5×10^{-5} rem TEDE, with an associated probability of an LCF of 2×10^{-8} (see Table G-16). Under Accident Scenario T5, the radiation dose to the noninvolved worker is 3×10^{-3} rem TEDE, with an associated probability of an LCF of 1×10^{-6}. Under Accident Scenario T6, the radiation dose to the noninvolved worker is 40 rem TEDE. The probability of an LCF for the WIPP noninvolved worker is 0.01.

Under Action Alternatives 2A and 2B, the potential hazardous chemical impacts would be greatest for the Hanford noninvolved worker for all accidents evaluated. Hazardous chemical carcinogenic impacts would be no greater than a 3×10^{-16}, 4×10^{-14}, and 1×10^{-8} probability of contracting cancer for Accidents T4, T5, and T6, respectively (see Table G-17). Noncarcinogenic impacts ratios of 1.0 or greater would indicate the potential for the noncarcinogenic impact. For Accident Scenario T6, the maximum ERPG-2 ratio is equal to 50 at Hanford for both mercury and lead. These two metals also have an ERPG-2 ratio of 40 at LANL and ORNL. The ERPG-3 ratios are greater than one for all but one of the six sites; therefore, these ratios indicate that life-threatening effects would be expected for Accident Scenario T6. The maximum IDLH-equivalent ratio for Accident Scenario T6 is 2×10^{-5} for the Hanford noninvolved worker. For Accident Scenario T4, the maximum ERPG-2 ratio for the noninvolved worker is 3×10^{-5} with a maximum IDLH-equivalent ratio of 1×10^{-11} and for Accident Scenario T5, the maximum ERPG-2 ratio for the noninvolved worker is 3×10^{-3} and the maximum IDLH-equivalent ratio is 1×10^{-9}. Therefore, the only serious impacts would be expected under the beyond-design-basis accident.

Under Action Alternative 2C, the potential hazardous chemical impacts would be to the WIPP noninvolved worker for all accidents evaluated. Hazardous chemical carcinogenic impacts are no greater than a 2×10^{-16}, 2×10^{-14}, and 4×10^{-9} probability of contracting cancer for accidents T4, T5, and T6, respectively (see Table G-17). Noncarcinogenic impacts ratios of 1.0 or greater would indicate the potential for the noncarcinogenic impact. For Accident Scenario T6, the maximum ERPG-2 ratio is equal to 20 for both mercury and lead and the ERPG-3 ratio is 1 for the WIPP site. Therefore, these ratios indicate that life-threatening effects would be expected for Accident Scenario T6. The maximum IDLH-equivalent ratio for Accident Scenario T6 is 5×10^{-6} for the WIPP noninvolved worker. For Accident Scenario T4, the maximum ERPG-2 ratio for the noninvolved worker is 2×10^{-5} with a maximum IDLH-equivalent ratio of 6×10^{-12}. For Accident Scenario T5, the maximum ERPG-2 ratio for the noninvolved worker is 2×10^{-3} and the maximum IDLH-equivalent ratio is 6×10^{-10}. Therefore, the only serious impacts would be expected under the beyond-design-basis accident.

Impacts to Maximally Exposed Involved Worker

No impacts to the maximally exposed involved worker would be anticipated from the waste spill (Accident Scenario T4). This accident is such that involved workers would be able to evacuate immediately or would not be affected by the event. The nature of the steam explosion (Accident Scenario T5) is such that an involved worker would be killed. Substantial impacts would be

possible from a beyond-design-basis earthquake (Accident Scenario T6), ranging from workers killed by debris from the collapsing treatment facilities to high external radiation doses from RH-TRU waste being treated and intakes of radionuclides, VOCs, and hazardous metals. Intakes of radionuclides could result in a dose of up to 14,800 rem, with a corresponding probability of an LCF of greater than 1. The probability of cancer from exposure to VOCs and hazardous metals would be 3×10^{-6} and 7×10^{-5}, respectively (see Table G-17). Noncarcinogenic impacts ratios of 1.0 or greater would indicate the potential for the noncarcinogenic impact. For VOCs, the maximum ERPG-2 ratio would be 110 and the maximum IDLH-equivalent ratio would be 3×10^{-3}. For hazardous metals, the maximum ERPG-2 ratio would be 475 (an ERPG-3 ratio of 28) and the maximum IDLH-equivalent ratio would be 3 (see Table G-18).

G.2.4.3 Treatment Accident Impacts for Action Alternative 3

The accident impacts from waste treatment by a shred and grout process are shown in Tables G-19 to G-21 and are discussed below for the population, MEI, maximally exposed noninvolved worker, and maximally exposed involved worker. These accident analyses apply only to Action Alternative 3. Radiological impacts from shred and grout treatment accidents are substantially higher than those for treatment to planning-basis WAC accidents and somewhat lower than thermal treatment accidents. Carcinogenic impacts from hazardous chemicals are low in all cases, but some life-threatening toxicological effects could occur in maximally exposed individuals during the postulated earthquake events.

Table G-19
Radiological Impacts from Treatment Accidents for Waste Treatment by Shred and Grout

Site	Accident Scenario T7 (Waste Spill)		Accident Scenario T8 (Fire in the Shredder)		Accident Scenario T9 (Earthquake)	
Population	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
Hanford	0.2	9E-5	1,900	1	19,000	10
INEL	8E-3	4E-6	90	0.05	930	0.5
LANL	0.07	4E-5	810	0.4	8,100	4
RFETS	0.2	9E-5	1,800	0.9	18,000	9
ORNL	0.3	1E-4	2,900	1	29,000	10
SRS	0.02	1E-5	200	0.1	2,000	1
MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
Hanford	5E-5	2E-8	0.5	2E-4	5	2E-3
INEL	4E-6	2E-9	0.04	2E-5	0.4	2E-4
LANL	1E-4	5E-8	1	5E-4	10	5E-3
RFETS	1E-5	5E-9	0.1	5E-5	1	5E-4
ORNL	2E-4	1E-7	2	1E-3	20	0.01
SRS	1E-6	5E-10	0.01	6E-6	0.1	6E-5
Maximally Exposed Noninvolved Worker						
Hanford	3E-4	1E-7	4	2E-3	40	0.02
INEL	7E-5	3E-8	0.8	3E-4	8	3E-3
LANL	3E-4	1E-7	3	1E-3	30	0.01
RFETS	6E-5	2E-8	0.6	2E-4	6	2E-3
ORNL	3E-4	1E-7	3	1E-3	30	0.01
SRS	1E-4	5E-8	1	5E-4	10	5E-3
Maximally Exposed Involved Worker						
Any Site	0	0	0	0	7,700	1

Table G-20
Hazardous Chemical Carcinogenic Impacts from Treatment Accidents for Waste Treatment by Shred and Grout

Site	Accident Scenario T7 (Waste Spill)		Accident Scenario T8 (Fire in the Shredder)		Accident Scenario T9 (Earthquake)	
	VOCs	Metals	VOCs	Metals	VOCs	Metals
Population	**Number of Cancers**		**Number of Cancers**		**Number of Cancers**	
Hanford	1E-7	8-13	0	1E-8	7E-6	1E-7
INEL	6E-9	3E-14	0	5E-10	4E-7	5E-9
LANL	5E-8	3E-13	0	4E-9	3E-6	4E-8
RFETS	2E-7	2E-12	0	2E-8	1E-5	2E-7
ORNL	2E-7	1E-13	0	1E-8	1E-5	1E-7
SRS	2E-8	1E-13	0	1E-9	1E-6	1E-8
MEI	**Probability of Cancer Incidence**		**Probability of Cancer Incidence**		**Probability of Cancer Incidence**	
Hanford	3E-11	2E-16	0	2E-12	2E-9	2E-11
INEL	2E-12	2E-17	0	2E-13	2E-10	2E-12
LANL	7E-11	4E-16	0	6E-12	4E-9	6E-11
RFETS	1E-11	9E-17	0	1E-12	9E-10	1E-11
ORNL	1E-10	8E-16	0	1E-11	8E-9	1E-10
SRS	9E-13	6E-18	0	8E-14	6E-11	8E-13
Maximally Exposed Noninvolved Worker						
Hanford	2E-10	2E-15	0	2E-11	1E-8	2E-10
INEL	4E-11	4E-16	0	5E-12	3E-9	5E-11
LANL	1E-10	1E-15	0	2E-11	9E-9	2E-10
RFETS	7E-11	6E-16	0	8E-12	4E-9	8E-11
ORNL	1E-10	1E-15	0	2E-11	9E-9	2E-10
SRS	9E-11	9E-16	0	1E-11	6E-9	1E-10
Maximally Exposed Involved Worker						
Any Site	0	0	0	0	3E-6	4E-5

Table G-21
Hazardous Chemical Noncarcinogenic Impacts from Treatment Accidents for Waste Treatment by Shred and Grout

Site	Accident Scenario T7 (Waste Spill)				Accident Scenario T8 (Fire in the Shredder)				Accident Scenario T9 (Earthquake)			
	VOCs		Metals		VOCs		Metals		VOCs		Metals	
MEI	**IDLH[a]**	**ERPG-2[b]**	**IDLH[a]**	**ERPG-2[b]**	**IDLH[a]**	**ERPG-2[b]**	**IDLH[a]**	**ERPG-2[b]**	**IDLH[a]**	**ERPG-2[b]**	**IDLH[a]**	**ERPG-2[b]**
Hanford	3E-8	0.03	7E-12	3E-5	0	0	9E-8	0.4	2E-6	2	9E-7	4
INEL	3E-9	2E-3	6E-13	2E-6	0	0	7E-9	0.03	2E-7	0.1	7E-8	0.3
LANL	7E-8	0.06	2E-11	7E-5	0	0	2E-7	0.9	5E-6	4	2E-6	9
RFETS	1E-8	0.01	3E-12	1E-5	0	0	4E-8	0.2	1E-6	0.8	4E-7	2
ORNL	1E-7	0.1	3E-11	1E-4	0	0	4E-7	2	9E-6	8	4E-6	20
SRS	1E-9	9E-4	2E-13	1E-6	0	0	3E-9	0.01	7E-8	0.06	3E-8	0.1
Maximally Exposed Noninvolved Worker												
Hanford	2E-7	0.2	6E-11	2E-4	0	0	8E-7	2	1E-5	10	8E-6	30
INEL	5E-8	0.04	1E-11	4E-5	0	0	2E-7	0.6	3E-6	3	2E-6	6
LANL	2E-7	0.1	5E-11	2E-4	0	0	6E-7	2	1E-5	9	7E-6	20
RFETS	7E-8	0.06	2E-11	7E-5	0	0	3E-7	0.9	5E-6	4	3E-6	9
ORNL	2E-7	0.1	5E-11	2E-4	0	0	6E-7	2	1E-5	9	7E-6	20
SRS	1E-7	0.09	3E-11	9E-5	0	0	4E-7	1	6E-6	6	4E-6	10
Maximally Exposed Involved Worker												
Any Site			N/A	N/A	N/A	N/A	N/A	N/A	3E-3	113	1	247

[a] The highest ratio of the receptor hazardous chemical intake to the IDLH-equivalent value.
[b] The highest ratio of the receptor hazardous chemical air concentration to the ERPG-2 value.

N/A = Not Applicable

Impacts to Population

The potential radiological impacts to the populations surrounding any site are greatest for ORNL (see Table G-19). This is due to a combination of the radionuclides determined to be significant at the ORNL site through screening calculations and the population-weighted dispersion factor for the population east of ORNL. No cancer fatalities would be expected from operational accident T7; population impacts from the waste spill range from 4 x 10-6 to 1 x 10-4 LCFs. Up to 1 LCF could be expected at Hanford, RFETS, or ORNL under operational accident T8, a fire in the shredder; population impacts range from 0.05 to 1 LCF. Because of the severity of the earthquake scenario (Accident Scenario T9), all but one of the sites would have some LCFs. The greatest number of LCFs would be 10 at ORNL or Hanford; for all sites, Accident Scenario T9 impacts could range from 0.5 to 10 LCFs.

The potential hazardous chemical impacts to the population are very small. No cancers are expected in the populations surrounding the six major sites as a result of the hazardous chemical or metal releases from any analyzed accident. Impacts range from 3×10^{-14} to 2×10^{-7} cancers for Accident Scenario T7, 5×10^{-10} to 2×10^{-8} cancers for Accident Scenario T8, and 5×10^{-9} to 1×10^{-5} cancers for Accident Scenario T9 (see Table G-20).

Impacts to Maximally Exposed Individual

The potential radiological impacts to the MEI would be greatest for ORNL for all the accident scenarios analyzed (see Table G-19), due to the combination of radionuclides determined to be significant at the ORNL site through screening calculations and the MEI air dispersion factor. In Accident Scenario T7, radiation doses to the MEI would range from 1×10^{-6} to 2×10^{-4} rem TEDE, with an associated probability of an LCF of 5×10^{-10} to 1×10^{-7}. In Accident Scenario T8, radiation doses to the MEI would range from 0.01 to 2 rem TEDE, with an associated probability of an LCF of 6×10^{-6} to 1×10^{-3}. In Accident Scenario T9, radiation doses to the MEI would range from 0.1 to 20 rem TEDE with an associated probability of an LCF of 6×10^{-5} to 0.01.

The potential hazardous chemical impacts are greatest at ORNL for Accident Scenarios T7, T8, and T9, because the MEI air dispersion factor is larger at ORNL than at any of the other sites and the inventories of hazardous chemicals and metals are assumed to be the same at all the sites. Overall, however, the carcinogenic impacts from the accidents would be very small, with a 1×10^{-10}, 1×10^{-11}, and 8×10^{-9} probability of contracting cancer for Accidents Scenarios T7, T8, and T9, respectively (see Table G-20). Noncarcinogenic impacts ratios of 1.0 or greater would indicate the potential for the noncarcinogenic impact. For Accident Scenario T9, the maximum ERPG-2 ratio is equal to 20 at ORNL and LANL for both mercury and lead (see Table G-21). Therefore, some irreversible impacts would be expected, but no life-threatening effects would be possible (maximum ERPG-3 ratio of 0.9). The maximum IDLH-equivalent ratio for Accident Scenario T9 is 4×10^{-6} for the ORNL MEI. For Accident Scenario T7, the maximum ERPG-2 ratio for the MEI is 0.1 and the maximum IDLH-equivalent ratio is 1×10^{-7}. For Accident Scenario T8, the maximum ERPG-2 ratio is 2 and the IDLH-equivalent ratio is 4×10^{-7}. Therefore, the only serious impacts would be expected under the beyond-design-basis accident.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological impacts are greatest for all accidents evaluated for the Hanford maximally exposed noninvolved worker (see Table G-19). The noninvolved worker impacts are

driven by the site-specific dispersion factor for this individual and by the site-specific mix of radionuclides chosen for the evaluation. Under Accident Scenario T7, the radiation doses to the maximally exposed noninvolved worker would range from 6×10^{-5} to 3×10^{-4} rem TEDE, with an associated probability of an LCF of 2×10^{-8} to 1×10^{-7}. Under Accident Scenario T8, the radiation doses to the noninvolved worker would range from 0.8 to 4 rem TEDE, with an associated probability of an LCF of 3×10^{-4} to 2×10^{-3}. Under Accident Scenario T9, the radiation doses to the noninvolved worker range from 8 to 40 rem TEDE to the noninvolved worker. The potential Accident Scenario T9 impacts to the LANL, ORNL and Hanford noninvolved worker would be the most serious. The probability of an LCF for the individuals at these sites would range from 3×10^{-3} to 0.02.

The potential hazardous chemical impacts are greatest for the Hanford maximally exposed noninvolved worker for all accidents evaluated (see Table G-20). Hazardous chemical carcinogenic impacts are no greater than 2×10^{-10}, 2×10^{-11}, and 1×10^{-8} probability of contracting cancer for Accident Scenarios T7, T8, and T9, respectively. Noncarcinogenic impacts ratios of 1.0 or greater would indicate the potential for the noncarcinogenic impact. For Accident Scenario T9, the maximum ERPG-2 ratio would be equal to 30 at Hanford for both mercury and lead (see Table G-21). These two metals also have an ERPG-2 ratio of 20 at LANL and ORNL. Therefore, some irreversible impacts would be expected as well as life-threatening effects (ERPG-3 ratios of one at Hanford, LANL, and ORNL). The maximum IDLH-equivalent ratio for Accident Scenario T9 would be 8×10^{-6} for the Hanford noninvolved worker. For Accident Scenario T7 the maximum ERPG-2 ratio for the noninvolved worker is 0.2 with a maximum IDLH-equivalent ratio of 2×10^{-7}. For Accident Scenario T8, the maximum ERPG-2 ratio for the noninvolved worker is 2 and the maximum IDLH-equivalent ratio is 8×10^{-7}. Therefore, the only serious impacts would be expected under the beyond-design-basis accident.

Impacts to Maximally Exposed Involved Worker

No impacts to the maximally exposed involved worker would be anticipated from either the waste spill (Accident Scenario T7) or the fire in the shredder (Accident Scenario T8) (see Table G-19). These accidents are such that involved workers would be able to evacuate immediately or would not be affected by the event. Substantial impacts would be possible from a beyond-design-basis accident, including workers killed by debris from the collapsing treatment facilities to high external radiation doses from RH-TRU waste being treated and intakes of radionuclides, VOCs, and hazardous metals. Intakes of radionuclides could result in a dose of up to 7,700 rem, with a corresponding probability of an LCF of greater than 1. The probability of cancer from exposure to VOCs and hazardous metals would be 3×10^{-6} and 4×10^{-5}, respectively (see Table G-20). Noncarcinogenic impacts ratios of 1.0 or greater would indicate the potential for the noncarcinogenic impact. For VOCs, the maximum ERPG-2 ratio would be 113 and the maximum IDLH-equivalent ratio would be 3×10^{-3}. For hazardous metals, the maximum ERPG-2 ratio would be 247 (an ERPG-3 ratio of 14) and the maximum IDLH-equivalent ratio would be 1 (see Table G-21) from mercury intakes.

G.3 STORAGE ACCIDENT SCENARIOS

The storage accident analyses were conducted to evaluate the potential accident consequences of storing TRU waste. Generic CH-TRU and RH-TRU waste storage facilities were assumed for all waste forms under all alternatives, because none of the facilities have yet been designed or

constructed. Site-specific NEPA evaluations and safety assessments would be conducted prior to facility construction and operation.

Under Action Alternative 1, Action Alternatives 2A, 2B, and 2C, Action Alternative 3, and No Action Alternative 2, waste storage activities would include moving the waste containers into storage, monitoring the waste for contamination on the outside of the containers, and relocating the waste while in storage to support monitoring and maintenance activities. Monitoring and maintenance activities would require workers to be near stored waste: monitoring activities would include visual inspections and swiping the outside of containers for contamination, and building maintenance activities would include maintaining roofs and preventing or removing build-up of combustibles at locations that could endanger the stored TRU waste. Accidents assessed during lag or indefinite storage included waste container breaches, a waste container fire, and a natural event. All three accidents were evaluated for CH-TRU waste at each storage location under each of these alternatives.

In addition to the above activities, CH-TRU waste would be overpacked at 20-year intervals (under No Action Alternatives 1A and 1B). No accidents were specifically evaluated for overpacking operations, although impacts would be bounded by other storage accident analyses. For example, impacts to the maximally exposed involved worker would probably be lower than under other alternatives because this worker was assumed to wear a HEPA-filtered mask and, therefore, would not inhale particulate radionuclides in the event of an overpacking accident.

The accident analyses concentrated on the consequences of events involving CH-TRU waste. RH-TRU waste canisters were assumed to be substantially more robust (cylinders with 6-millimeter [0.24-inch] thick carbon-steel walls) than CH-TRU waste containers because of both the greater handling hazard (high external radiation dose rates) of RH-TRU waste and the reduced likelihood that the canister would be breached during a minor impact event. RH-TRU waste storage facilities were assumed to withstand severe conditions introduced by humans or a natural disaster. It was assumed there would be remote monitoring of the RH-TRU waste and that there would be no overpacking of RH-TRU waste canisters under No Action Alternatives 1A and 1B. Therefore, except for the beyond-design-basis natural disaster, no conditions were believed to exist that would lead to the environmental release of RH-TRU waste during storage operations. The most severe accidental exposure involving RH-TRU waste during storage would be that of a maximally exposed involved worker who remained for an extended period of time in an elevated radiation area near RH-TRU waste canisters.

Under the Proposed Action only RH-TRU waste would be stored. The RH-TRU waste storage facilities would be constructed to maintain waste containment during all but the most severe circumstances. The current RH-TRU waste containers are designed to result in only a minor breach during a significant impact event. It was assumed that, at a minimum, a similar design would be used at Hanford and ORNL. Site-specific NEPA review and safety analyses conducted prior to facility construction and operation would require detailed accident risk calculations for the storage facility.

Accident Scenario S1, a drum puncture and lid failure, would be a relatively high-frequency incident. The estimated annual frequency of occurrence would be 1×10^{-2} to 1×10^{-4}. This estimated frequency, taken from DOE (1995b), was developed for the handling of waste containers during WIPP disposal operations. Storage operations would require handling of waste during the year it enters storage, the year it leaves storage, and on an infrequent basis during the monitoring

phase. Therefore, for waste containers that are in the storage facility for more than two years, the average frequency of occurrence would be expected to decrease somewhat over time.

Accident Scenario S2, a drum fire, is not expected to occur but was evaluated to address public concerns. The WIPP disposal operations frequency of occurrence estimate for a drum fire is 1×10^{-4} to 1×10^{-6} for planning-basis WAC waste (DOE 1995b). This same estimate is applied to planning-basis WAC waste in interim storage. The accident is not applicable to thermally treated waste, which contains no combustible materials, and is likely not applicable to grouted waste, which has limited combustibility.

Accident Scenario S3, a beyond-design-basis earthquake, has an estimated annual frequency of occurrence of 1×10^{-5} or less. This accident frequency does not vary by waste treatment level.

G.3.1 Inventory

The inventory of materials in stored waste that could potentially cause human health impacts includes both radionuclides and hazardous chemicals. One purpose in developing the planning-basis WAC (DOE 1996a) was to ensure that all DOE sites package TRU waste to meet a minimum standard that assures the safe transport, handling, and disposal of TRU waste. Some key planning-basis WAC requirements that limit the inventory of high-risk constituents packaged in waste containers and, thereby, reduce the accident impacts are presented in Table G-22.

Table G-22
Planning-Basis WAC Requirements that Reduce Accident Risk

Requirement	Comment
Liquids- Waste shall contain as little residual liquid as is reasonable achievable.	This requirement reduces the risk of exposure to hazardous constituents in the event of a container breach and reduces the uncertainty associated with the long-term performance of the WIPP facility.
Pyrophoric materials - No non-radionuclide pyrophorics are permitted. Radionuclides in pyrophoric form are limited to < 1 percent by weight in each waste package.	This requirement increases the stability of the waste.
Explosives and Compressed Gases - No explosives or compressed gases are permitted.	This requirement increases the stability of the waste.
Ignitable, Corrosive, and Reactive Hazardous Materials - EPA-defined characteristic ignitable, corrosive, or reactive wastes are not permitted.	This requirement increases the stability of the waste.
Criticality - Acceptable package limits are less than 200 fissile-gram-equivalents (FGE) per drum and less than 325 FGEs per standard waste box.	This requirement eliminates the risk of a nuclear criticality during transport and storage.
PE-Ci Limits - CH-TRU waste packages: Drum: 80 PE-Ci Standard Waste Box: 130 PE-Ci Drum overpacked in a Standard Waste Box or a Ten-Drum-Overpack: 1,800 PE-Ci Solidified/vitrified waste: 1,800 PE-Ci RH-TRU waste packages: 1,000 PE-Ci	Since the major exposure pathway from a container breach is inhalation and the major constituents of concern are transuranics, this requirement limits the potential radiological impacts in the event of a container breach.
Gas generation - Numerous requirements limit the amount of explosive gases that could accumulate in the interior of a waste package, including the requirement to vent all TRU waste packages.	This requirement increases the stability of the waste.

Accident impacts were estimated using bounding container inventories of radioactive and hazardous chemicals, when these inventories were defined by the planning-basis WAC. For some VOCs and all the hazardous metals, container limits were not defined. In such cases, the container inventories were estimated as described below.

G.3.1.1 Radionuclide Inventory

The quantity of radionuclides in waste containers was assumed to be the PE-Ci limits of the planning-basis WAC (DOE 1996b) for all accident scenarios, including those of the no action alternatives. Nonsolidified CH-TRU waste drums are limited to 80 PE-Ci, CH-TRU waste standard waste boxes are limited to 130 PE-Ci, and RH-TRU waste canisters are limited to 1,000 PE-Ci. Radionuclide activities at these limits were assumed to be present in all waste containers evaluated. Vitrified and solidified final waste forms under Action Alternatives 2A, 2B, and 2C and Action Alternative 3 are limited to 1,800 PE-Ci. Current TRUPACT-II thermal power limits, however, do not allow transport of waste drums with 1,800 PE-Ci so the nonsolidified limits were applied to waste under these alternatives.

Estimated average drum PE-Ci contents for the existing TRU waste inventory are much lower than the current planning-basis WAC limits. The average radionuclide PE-Ci contents at the major treatment sites and WIPP are presented in Tables G-23 and G-24 for CH-TRU and RH-TRU waste, respectively. Because the accident analyses are intended to evaluate reasonably bounding events, however, the planning-basis WAC inventory limit was used for events involving a small number of containers. Accidents involving a large number of containers (i.e., an earthquake) were evaluated using the site-specific PE-Ci container averages.

Comparison of Tables G-23 and G-24 shows that the average PE-Ci content of RH-TRU waste is typically lower than that of CH-TRU waste. RH-TRU waste contains greater quantities of fission product radionuclides that emit penetrating radiation like X- or gamma radiation that produce the high external dose rates and require the waste to be remotely handled. However, most of the potential radiation dose and radiological impacts from radionuclide releases would result from inhalation, not from external dose, so fission product radionuclides are small contributors to the PE-Ci inventory compared to transuranic radionuclides. The fission products contributing the most to external dose rates were Cs-137/Ba-137m and Co-60, with smaller but important contributions from europium-152 (Eu-152) and europium-154 (Eu-154) at some consolidation sites.

Table G-23
Average Radionuclide Content of CH-TRU Waste
(PE-Ci per drum-equivalent) at the Major Storage Sites and WIPP

Site	Proposed Action	Action Alternative 1	Action Alternative 2A & No Action Alternative 1A	Action Alternative 2B & No Action Alternative 1B	Action Alternative 3	No Action Alternative 2
Hanford	2.2	1.9	5.3	5.3	1.6	1.9
INEL	1.8	1.5	3.3	6.9	1.3	1.5
LANL	4.3	3.6	10	N/A	3.1	3.7
ORNL	2.0	2.0	N/A	N/A	N/A	1.7
RFETS	13	7.6	35	N/A	7.0	12
SRS	14	12	29	29	8.6	18
WIPP	3.5	2.9	7.7[a]	7.7[a]	2.5	4.3

[a] WIPP is the only storage site for CH-TRU waste, so this is the CH-TRU value under Action Alternative 2C.

N/A = Not Applicable

Table G-24
Average Radionuclide Content of RH-TRU Waste
(PE-Ci per canister) at the Major Storage Sites and WIPP

Site	Proposed Action	Action Alternative 1	Action Alternative 2 & No Action Alternative 1	Action Alternative 3	No Action Alternative 2
Hanford	0.3	3.7	9.9	2.9	3.7
INEL	0.6	0.6	N/A	N/A	0.6
LANL	0.9	0.9	N/A	N/A	0.9
ORNL	0.1	0.3	0.9	0.3	0.4
WIPP	0.3	3.0	8.6	2.5	N/A

N/A = Not Applicable

G.3.1.2 Hazardous Chemical Inventory

Hazardous chemicals that may be present in TRU waste are volatile organic compounds and hazardous metals, including lead, mercury, beryllium, and cadmium. The planning-basis WAC includes limits for several VOCs based on their flammability and their health risk, as determined by the RCRA Part B Application health impact analyses (DOE 1996a). No limits are included in the planning-basis WAC for the four hazardous metals of concern.

Volatile Organic Compounds

VOCs were assumed to be present in all waste treated to planning-basis WAC and the shred and grout process; VOCs, however, would be present in waste after thermal treatment (Action Alternative 2). Maximum headspace concentrations of VOCs were assumed for accidents involving relatively small numbers of waste containers. The presence of a maximum headspace concentration of a specific VOC would have no bearing on whether another VOC would be found in the same container at a high concentration. VOCs with specific planning-basis WAC limits (carbon tetrachloride, chloroform, and methylene chloride) were assumed to be present at the maximum allowable headspace concentrations. Flammable VOCs (1,1-dichloroethylene, 1,2-dichloroethane, benzene, ethyl benzene, and xylene) were assumed to be present at a maximum concentration of 500 parts per million (ppm). Other VOCs likely to be present in the waste were assumed to be at concentrations equivalent to the maximum headspace concentration found in solidified organic samples, because solidified organics have the highest headspace concentrations of all waste matrix categories. Average VOC headspace concentrations were assumed for accidents involving a large number of waste containers, such as natural disasters. VOC headspace concentrations are presented in Table G-25. VOCs may be present in RH-TRU waste as well as CH-TRU waste. Because of the lack of sampling information, VOC concentrations in RH-TRU waste were assumed to be identical to those in CH-TRU waste.

A screening calculation was performed to identify VOCs with the greatest potential impacts from an acute exposure event. Impacts from acute hazardous chemical exposures were evaluated as potentially both carcinogenic and noncarcinogenic. As described in Section G.1.2.3, screening for carcinogenic impact was performed by multiplying the VOC headspace concentration by the EPA slope factor; noncarcinogenic impact screening was performed by comparing two different impacts measures, IDLH-equivalent intakes and ERPG-2 values. Only the VOCs that would contribute to the major potential impacts from an accidental release (greater than 90 percent) were included in the detailed evaluation (see Table G-26). For waste treated to planning-basis WAC (Proposed

Table G-25
VOC Headspace Concentrations in Treated TRU Waste

VOC[a]	Planning-Basis WAC Limit for Headspace Concentration (ppmv)[b]	Waste Treated to Meet Planning-Basis WAC (ppmv)		Treated by Shred and Grout (ppmv)	
		Weighted Average	Maximum[c]	Average	Maximum[d]
Carbon tetrachloride (6.39)	7,510	184.5	---	316.5	---
Chloroform (4.96)	6,325	13.7	---	1.2	---
1,1-dichloroethene (4.03)	500[e]	8.4	---	2.5	---
1,2-dichloroethane (4.11)	500[e]	5.6	---	1.1	---
Methylene chloride (3.53)	368,500	662.1	---	8.1	---
Chlorobenzene (4.68)	no limit	8.4	4,368	1.3	260
Methyl ethyl ketone (3.0)	no limit	40.4	39,311	6.8	130
1,1,2,2-tetrachloroethane (7.0)	no limit	335.7	4,368	125.1	270
Toluene (3.83)	no limit	5.7	6,992	1.3	320
Benzene (3.25)	500[e]	7.6	---	22.4	---
Ethyl benzene (4.41)	500[e]	8.5	---	31.6	---
Tetrachloroethene (6.89)	no limit	7.1	2184	21.6	600
Xylene (4.41)	500[e]	25.6	---	113.9	---

[a] Values in parentheses are milligram/cubic meter per ppm conversion factors.
[b] DOE 1996b.
[c] Maximum values for those VOCs without a maximum planning-basis WAC limit. Values are maximum concentrations found in any solidified organic sampled and were used for the bounding accident scenarios.
[d] Maximum concentration found in any solidified inorganic matrix for those VOCs without a planning-basis WAC limit.
[e] Flammable VOC limit.

Action, Action Alternative 1, No Action Alternative 2), methylene chloride would be the major contributor to toxicological impacts and 1,1,2,2-tetrachloroethane would be the main contributor to carcinogenic impacts. For grouted waste (Action Alternative 3), the major contributor to both toxicological and carcinogenic impacts would be methylene chloride. The scoping measure for which these VOCs would be the major contributor are also indicated in Table G-26.

Hazardous Metals

The inventory of metals in the waste was derived from estimates developed for the SAR (DOE 1995b). The SAR assumed a conservatively high concentration of metals in the waste for analysis of a waste fire. The waste form used for the SAR was the planning-basis WAC. These values were used as the basis for estimating hazardous metal inventories of thermally treated waste and waste treated by a shred and grout process (see Appendix A). Waste form and alternative-specific hazardous metal inventories of lead, beryllium, cadmium, and mercury are presented in Table G-27. The metals were assumed to be uniformly mixed in the waste containers (see Appendix A).

Table G-26
VOCs with Major Impact Contribution for Storage Accidents[a]

	Planning-Basis WAC Waste	Grouted Waste
VOCs	Methylene chloride (IDLH, ERPG-2) 1,1,2,2-tetrachloroethane (slope factor) Carbon tetrachloride Chloroform Chlorobenzene Benzene Ethyl benzene Tetrachloroethene	Methylene chloride (slope factor, IDLH, ERPG-2) Carbon tetrachloride Chloroform 1,1-dichloroethene Benzene Ethyl benzene Tetrachloroethene

[a] The risk measure in parentheses identifies the VOC with the greatest screening value for that measure.

Table G-27
Hazardous Metal Concentrations in Treated TRU Waste

	Concentration (kilograms per drum-equivalent)[a]			
	Waste Treated to Planning-Basis WAC		Thermally Treated Waste	Waste Treated by Shred and Grout Process
Hazardous Metals	Proposed Action	Action Alternative 1	Action Alternative 2	Action Alternative 3
Lead	1.0	0.97	2.6	0.81
Beryllium	0.025	0.025	0.065	0.021
Cadmium	3.6E-4	3.5E-4	9.3E-4	3.0E-4
Mercury	0.43	0.42	1.1	0.35

[a] One drum-equivalent contains 0.208 cubic meters of waste.

G.3.2 Storage Accident Analyses

This section describes the three storage accident scenarios for waste treated to meet the planning-basis WAC, with descriptions of the scenarios as they apply to thermally treated waste or waste that has been treated by a shred and grout process.

Accident Scenario S1 - Container Puncture, Drop, and Lid Failure

In this accident scenario, operator error causes a forklift to strike and puncture two drums during placement or relocation of waste containers. As a result, a third drum falls from the stack and its lid is knocked off upon impact with the floor. It was assumed that 10 percent of the waste spills out of the punctured containers and 25 percent of the waste spills out of the lidless container; thus, 0.001 of the spilled fraction resuspends in the room air, 0.1 of which is respirable. Particulates releases from the facility were assumed to be HEPA-filtered, with a transmission factor of 1×10^{-3}. All headspace VOCs were assumed to be released.

For waste that has been thermally treated and waste that has been treated by a shred and grout process, no particulate release would be expected from the punctured drums. The lidless drum analyses assumed brittle fracture of the uniformly mixed mass as a result of the fall. Twenty-five

percent of the fractured waste was assumed to spill from the container with a respirable resuspension fraction value of 1×10^{-5}, an appropriate value for fractured brittle material (DOE 1994a). VOCs are not present in the thermally treated waste, but all headspace VOCs in the waste treated by a shred and grout process were assumed to be released from all three involved containers.

Accident Scenario S2 - Container Fire

In this scenario, it was assumed that the contents of a single container undergo spontaneous combustion and the mechanism initiating this event is unknown. Past instances of spontaneous combustion at DOE sites have included pyrophoric or incompatible materials reacting in a container, static electricity, and nitric acid reactions (Silva 1991). Packaging activities should preclude this scenario, but an analysis was conducted on a "what-if" basis without regard to likelihood of initiation. It was assumed that 5×10^{-4} of the radioactive and hazardous metals were resuspended as repirable particles, which is the more conservative value of the fraction of respirable particles expected from the burning of either combustible or noncombustible materials (DOE 1994a). The particles released are subject to a relatively high amount of deposition due to the heated aerosol reacting with the relatively cool surfaces within the facility; a deposition factor of 0.6 was assumed. In DOE (1990), it was assumed that 80 percent of the heated aerosol deposited on surfaces prior to release from an underground container fire. Nonthermal underground releases were assumed to deposit a net of 20 percent of the release prior to environmental release. Therefore, a surface facility fire was assumed to deposit the 60 percent difference of these two underground-release deposition values. Particulates released from the facility were assumed to be HEPA-filtered, with a transmission factor of 1×10^{-3}. VOCs were assumed to be consumed by the fire.

This scenario does not apply to thermally treated waste because it is not combustible. Waste treated by a shred and grout process is unlikely to combust, but calculations were performed to bound the accident case. It was assumed that 22 percent of the grouted waste would be transformed to a powder as a result of a 650+ degree Celsius fire (DOE 1994a). A respirable resuspension fraction of 6×10^{-5} was used and reflects the fraction of a heated powder resuspended by the vapor flux generated by an open fire. As with the accident analysis for waste treated to planning-basis WAC, all VOCs in the grouted waste headspace were assumed to be consumed by the fire.

Accident Scenario S3 - Earthquake

The storage facilities were assumed to withstand a certain magnitude of earthquake impact (i.e., a design-basis earthquake). This scenario, however, assumes a beyond-design-basis earthquake impact to each storage facility, resulting in loss of confinement capability and structural failure. Although the total site-specific volume of treated waste could be in the storage facility at the time of the seismic event, it was assumed the structure collapses on the waste containers and breaches 25 percent of the drums. Except for the thermally treated waste under No Action Alternative 1, it is unlikely that any site would have the total volume of treated waste in storage at any one point in time.

Release estimates were based on the site-specific average PE-Ci inventories (see Table G-23). The breached drums were assumed to release all headspace VOCs, and an average of 25 percent of the contents were assumed to spill from the breached drums. Approximately 1×10^{-4} of the spilled

contents would resuspend as respirable particulates, half of which were assumed to escape the collapsed structural debris and be released to the environment. For the thermally treated waste and waste treated by a shred and grout process, a portion in the containers was assumed to brittle-fracture as a result of the building collapse. An average of 10 percent of the drum contents was assumed to spill out of the breached containers and 1×10^{-5} of the spilled contents resuspended as respirable particulates.

Impact estimates for this scenario are more limited than those of the other storage accident scenarios. For the hazardous chemical impacts, only carcinogenic impacts and the IDLH-equivalent ratio impacts are estimated. No ERPG ratios were calculated because of the catastrophic nature of the accident: physical injury or fatalities would be expected for those in the facility as a result of the structural failure, and significant amounts of particulates would be suspended in the air, making suspect any estimated ERPG-2 ratios.

G 3.3 Impacts of Storage Accidents

Impacts of waste storage accidents were estimated for the MEI, the maximally exposed noninvolved worker, maximally exposed involved worker, and the exposed off-site population around each of the possible storage sites. Inhalation was the only exposure pathway considered for radionuclides, hazardous metals, and VOCs. Acute releases were assumed to be dispersed in one direction, so population impacts were estimated for a single, maximally exposed 22.5-degree sector (out to 80 kilometers [50 miles]) and not for the entire 80-kilometer (50-mile) region population. Population-weighted atmospheric dispersion values were calculated and used to determine the maximally impacted sector, considering both the change in air concentration over distance and the population distribution in the sector. Radiological impacts are reported as the TEDE, the number of LCFs in an exposed population, and the probability or percent chance of an LCF in an individual. Carcinogenic hazardous chemical impacts are similarly reported as the number of cancers occurring in the exposed population and as the probability or percent chance of a cancer occurring in an individual. Noncarcinogenic impacts are presented as the ratio of receptor air concentration to ERPG-2 value for VOC exposures, and as the ratio of receptor intake to IDLH-equivalent intake for both VOCs and hazardous metals exposures. Ratios of 1.0 or higher are significant for a noncarcinogenic impact. Accident impacts were estimated using conservative or bounding input and parameter values and, thus, will likely overestimate the impacts that could occur.

G.3.3.1 Storage Accident Impacts for Action Alternative 1 and No Action Alternative 2

The impacts of storage accidents for waste treated to meet the planning-basis WAC are presented in Tables G-28 to G-30. Table G-28 indicates the radiological impacts. Table G-29 indicates the carcinogenic impacts as a result of the VOC and metals exposures. Table G-30 indicates the noncarcinogenic impacts, indicated as the maximum IDLH-equivalent ratio and the maximum ERPG-2 ratio, for maximally exposed workers under Action Alternative 1 and No Action Alternative 2, assuming that newly generated waste under the latter would be packaged to meet the planning-basis WAC. Impacts presented in this section for Action Alternative 1 and No Action Alternative 2 would bound potential impacts of RH-TRU waste storage accidents under the Proposed Action.

Table G-28
Radiological Impacts from Storage Accidents for Waste Treated to Planning-Basis WAC (Action Alternative 1 and No Action Alternative 2)

Sites	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)	
Population	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**	**Dose (person-rem)**	**Number of LCFs**
Hanford	0.47	2E-4	2.1	1E-3	450,000	200
INEL	0.023	1E-5	0.10	5E-5	13,000	6
LANL	0.20	1E-4	0.91	5E-4	110,000	50
RFETS	0.94	5E-4	4.2	2E-3	510,000	300
ORNL	0.68	3E-4	3.0	2E-3	12,000	6
SRS	0.068	3E-5	0.30	2E-4	58,000	30
MEI	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**	**Dose (rem)**	**Probability of an LCF**
Hanford	1.2E-4	6E-8	5.3E-4	3E-7	110	0.06
INEL	1.0E-5	5E-9	4.3E-5	2E-8	5.3	3E-3
LANL	2.8E-4	1E-7	1.2E-3	6E-7	150	0.07
RFETS	5.5E-5	3E-8	2.5E-4	1E-7	30	0.02
ORNL	5.1E-4	3E-7	2.3E-3	1E-6	9.0	4E-3
SRS	4.0E-6	2E-9	1.7E-5	8E-9	3.2	2E-3
Maximally Exposed Noninvolved Worker						
Hanford	1.1E-3	4E-7	4.9E-3	2E-6	1,050	0.7
INEL	2.4E-4	1E-7	1.1E-3	4E-7	130	0.05
LANL	8.6E-4	3E-7	3.8E-3	2E-6	450	0.2
RFETS	3.9E-4	2E-7	1.7E-3	7E-7	210	0.09
ORNL	8.6E-4	3E-7	3.8E-3	2E-6	15	6E-3
SRS	5.3E-4	2E-7	2.4E-3	9E-7	450	0.2
Maximally Exposed Involved Worker						
Any Site	180	0.07	See Text	See Text	See Text	See Text

Impacts to Population

The greatest potential radiological impacts to the population surrounding any site are for RFETS (see Table G-28). This result is driven by the population-weighted dispersion factor of the area southeast of the RFETS site, which considers the distance and location of the population. Locations with higher populations at closer distances will result in higher population-weighted dispersion factors. Containers with bounding radionuclide inventories involved in container breach (Accident Scenario S1) or container fire (Accident Scenario S2) accidents are not expected to result in any latent cancer fatalities at RFETS or any other site. Accident Scenario S1 population impacts could range from 1×10^{-5} to 3×10^{-4} LCFs, and Accident Scenario S2 population impacts could range from 5×10^{-5} to 2×10^{-3} LCFs. The catastrophic earthquake scenario (Accident Scenario S3) could result in up to 300 LCFs in the RFETS population. For all sites, Accident Scenario S3 impacts could range from 6 to 300 LCFs.

The potential hazardous chemical impacts to the population are very small: 7×10^{-14} to 2×10^{-6} cancers under Accident Scenario S1, 3×10^{-13} to 1×10^{-11} cancers under Accident Scenario S2, and 1×10^{-6} to 2×10^{-3} cancers under Accident Scenario S3 (see Table G-29). Therefore, no cancers are expected in the populations surrounding the six major sites as a result of the hazardous chemical releases of any analyzed accident.

Table G-29
Hazardous Chemical Carcinogenic Impacts from Storage Accidents for Waste Treated to Planning-Basis WAC (Action Alternative 1 and No Action Alternative 2)

Sites	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)	
	VOCs	Metals	VOCs [a]	Metals	VOCs	Metals
Population	**Number of Cancers**		**Number of Cancers**		**Number of Cancers**	
Hanford	9E-7	1E-12		6E-12	2E-3	5E-5
INEL	4E-8	7E-14		3E-13	6E-5	2E-6
LANL	4E-7	6E-13	N/A	3E-12	2E-4	7E-6
RFETS	2E-6	3E-12		1E-11	5E-4	2E-5
ORNL	1E-6	2E-12		9E-12	4E-5	1E-6
SRS	1E-7	2E-13		9E-13	3E-5	1E-6
MEI	**Cancer Incidence**		**Cancer Incidence**		**Cancer Incidence**	
Hanford	2E-10	3E-16		2E-15	4E-7	1E-8
INEL	2E-11	3E-17		1E-16	2E-8	8E-10
LANL	5E-10	8E-16	N/A	4E-15	3E-7	9E-9
RFETS	2E-10	2E-16		7E-16	3E-8	9E-10
ORNL	9E-10	1E-15		7E-15	3E-8	1E-9
SRS	7E-12	1E-17		5E-17	2E-9	6E-11
Maximally Exposed Noninvolved Worker						
Hanford	1E-9	3E-15		1E-14	3E-6	1E-7
INEL	3E-10	7E-16		3E-15	4E-7	2E-8
LANL	1E-9	2E-15	N/A	1E-14	6E-7	3E-8
RFETS	5E-10	1E-15		5E-15	1E-7	7E-9
ORNL	1E-9	2E-15		1E-14	4E-8	2E-9
SRS	7E-10	2E-15		7E-15	2E-7	9E-9
Maximally Exposed Involved Worker						
Any Site	5E-7	5E-10	N/A	See Text	See Text	See Text

[a] VOCs are assumed to be consumed by the fire under Accident Scenario S2.

N/A = Not Applicable

Table G-30
Hazardous Chemical Noncarcinogenic Impacts from Storage Accidents for Waste Treated to Planning-Basis WAC (Action Alternative 1 and No Action Alternative 2)

Sites	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)
	Maximum IDLH-Equivalent Ratio	Maximum ERPG-2 Ratio	Maximum IDLH-Equivalent Ratio	Maximum ERPG-2 Ratio	Maximum IDLH-Equivalent Ratio
MEI					
Hanford	3E-6	1E-3	5E-11	2E-4	5E-4
INEL	2E-7	9E-3	4E-12	2E-5	3E-5
LANL	7E-6	3E-1	1E-10	5E-4	3E-4
RFETS	1E-6	5E-2	3E-11	1E-4	3E-5
ORNL	1E-5	5E-1	2E-10	1E-3	4E-5
SRS	9E-8	4E-3	2E-12	7E-6	2E-6
Maximally Exposed Noninvolved Worker					
Hanford	2E-5	7E-1	5E-10	2E-3	5E-3
INEL	4E-6	2E-1	1E-10	3E-4	7E-4
LANL	1E-5	6E-1	4E-10	1E-3	1E-3
RFETS	7E-6	3E-1	2E-10	5E-4	2E-4
ORNL	1E-5	6E-1	4E-10	1E-3	6E-5
SRS	9E-6	6E-1	2E-10	7E-4	3E-4
Maximally Exposed Involved Worker					
Any Site	4E-3	7	See Text	See Text	See Text

Impacts to Maximally Exposed Individual

The greatest potential radiological impacts to the MEI for Accident Scenarios S1 and S2 are for ORNL, and the greatest potential radiological impacts to the MEI for Accident Scenario S3 are for LANL (see Table G-28). The site of maximum impact changes for Accident Scenario S3, because these impacts are dependent on site-specific volumes of stored waste and average PE-Ci levels. Accidents Scenarios S1 and S2 assume the same waste volume and PE-Ci levels for each site-specific accident. In contrast to the population impacts discussed above, the change in the MEI dispersion factors for each site is less than the site-specific waste characteristics. Therefore, the MEI impacts are driven more by site-specific waste characteristic changes than by the dispersion factors. Under Accident Scenario S1, radiological doses to the MEI would range from 4×10^{-6} to 5×10^{-4} rem TEDE, with an associated probability of an LCF of 5×10^{-9} to 3×10^{-7}. Under Accident Scenario S2, radiological doses to the MEI would range from 2×10^{-5} to 2.3×10^{-3} rem TEDE, with an associated probability of an LCF of 8×10^{-9} to 1×10^{-6}. Accident Scenario S3 results in an estimated 3.2×10^{-3} to 0.15 rem TEDE to the MEI and a 2×10^{-6} to 7×10^{-5} probability of an LCF.

The greatest potential hazardous chemical impacts to the MEI are for ORNL under Accident Scenarios S1 and S2, and the greatest potential chemical impacts to the MEI under Accident Scenario S3 are for Hanford. The site of maximum hazardous chemical impact changes for Accident Scenario S3 because of the site-specific parameters of the Accident Scenario S3 analyses. The hazardous chemical inventory of each site is assumed to be constant but the impacted volume changes. The waste volume impacted at Hanford drives the Accident Scenario S3 impact results.

The potential hazardous chemical impacts to the MEI are very small: carcinogenic impacts are no greater than a 9×10^{-10}, 7×10^{-15}, and 4×10^{-7} probability of contracting cancer for Accident Scenarios S1, S2, and S3, respectively (see Table G-28). Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for a noncarcinogenic impact. For Accident Scenario S1 noncarcinogenic impacts, the maximum ERPG-2 ratio is 0.5 for ORNL for both methylene chloride and 1,1,2,2-tetrachloroethane. Therefore, no serious or irreversible impacts would be expected. Also, no mild transient health impacts or objectionable odors would be expected for this ORNL MEI (maximum ERPG-1 ratio of 0.8 for 1,1,2,2-tetrachloroethane). The maximum IDLH-equivalent ratio for Accident Scenario S1 is 1×10^{-5} (see Table G-30). Under Accident Scenario S2, the maximum ERPG-2 ratio for the MEI is 1×10^{-3} and the maximum IDLH-equivalent ratio is 2×10^{-10}. Only ERPGs for metals are considered under the Accident Scenario S2 analyses. Under Accident Scenario S3, the maximum IDLH-equivalent ratio is 5×10^{-4} for the Hanford MEI. Therefore, no serious noncarcinogenic impacts are expected from hazardous chemical exposures under any of the three accident scenarios evaluated.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological impacts are greatest for all accidents evaluated for the Hanford noninvolved worker (see Table G-28). The noninvolved worker impacts are driven by the site-specific dispersion factor for this individual. Under Accident Scenario S1, radiological doses to the maximally exposed noninvolved worker would range from 2×10^{-4} to 1×10^{-3} rem TEDE, with an associated probability of an LCF of 1×10^{-7} to 4×10^{-7}. Under Accident Scenario S2, radiological doses to the noninvolved worker would range from 1×10^{-3} to 5×10^{3} rem TEDE with an associated probability of an LCF of 4×10^{-7} to 2×10^{-6}. Accident Scenario S3 results in an estimated 15 to 1,000 rem TEDE to the noninvolved worker; therefore, the potential Accident

Scenario S3 impacts to the LANL, SRS, and Hanford noninvolved worker would be the most serious. The first-year dose at these sites is greater than 20 rem (22.5 rem for LANL and SRS and 52.5 rem for Hanford), which increases their LCF risk for that year by a factor of two. The probability of an LCF for the individuals at these sites are 0.2 for LANL and SRS and 0.7 for Hanford.

The potential hazardous chemical impacts are greatest for the Hanford maximally exposed noninvolved worker for all accidents (see Table G-29). Rounding of Accident Scenarios S1 and S2 impacts for the LANL and ORNL noninvolved workers also gives carcinogenic impacts that are equivalent to those of the Hanford noninvolved worker. The potential hazardous chemical impacts to the noninvolved worker are very small, with a 1×10^{-9}, 1×10^{-14}, and 3×10^{-6} probability of contracting cancer for Accident Scenarios S1, S2, and S3, respectively. The Accident Scenario S3 impacts are attributable to the 1,1,2,2-tetracholorethane releases. Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for a noncarcinogenic impact. For Accident Scenario S1 noncarcinogenic impacts, the maximum ERPG-2 ratio is 0.7 for Hanford for both methylene chloride and 1,1,2,2-tetrachloroethane releases. Therefore, no serious or irreversible impacts would be expected. Mild transient health impacts or objectionable odors would be expected for this Hanford noninvolved worker (maximum ERPG-1 ratio of 1.2 for 1,1,2,2-tetrachloroethane). The maximum IDLH-equivalent ratio for Accident Scenario S1 is 2×10^{-5}. Under Accident Scenario S2, the maximum ERPG-2 ratio for the noninvolved worker is 2×10^{-3} and the maximum IDLH-equivalent ratio is 5×10^{-10}. Under Accident Scenario S3, the maximum IDLH-equivalent ratio is 5×10^{-3} for the Hanford MEI. No serious noncarcinogenic impacts are expected from hazardous chemical exposures under any of the three accident scenarios evaluated.

Impacts to Maximally Exposed Involved Workers

Accident impacts were estimated quantitatively for the maximally exposed involved worker only for Accident Scenario S1. The drum drop was assumed to occur 3 meters (9.9 feet) from the worker and the estimated release of the three involved containers was assumed to expand in a uniform hemisphere. The worker was assumed to inhale approximately five breaths prior to exiting to a fresh air source. For waste packaged to meet the planning-basis WAC, the worker would receive a dose of 180 rem TEDE with an associated probability of an LCF of 0.07. The maximum first-year dose from such an intake would be 9 rem. Carcinogenic impacts from VOC and hazardous metal intakes would be a 3×10^{-7} and 5×10^{-10} probability of a cancer incidence, respectively. Releases could have irreversible, non-life-threatening impacts from exposure to 1,1,2,2-tetrachloroethane (ERPG-2 ratio of 7) or lead and mercury (ERPG-2 ratios of 3 for both). Bounding methylene chloride exposures could seriously threaten the involved worker (ERPG-3 ratio of 3). Noncarcinogenic impacts evaluated according to IDLH-equivalent intake ratios do not indicate that any impact would result (maximum ratio of 4×10^{-3}).

If the maximally exposed involved worker were located next to a drum fire (Accident Scenario S2) when it erupted, the impacts would be severe. However, the probability that this scenario would occur is minute. The smoke would be apparent and the worker can be presumed to exit the facility immediately.

If the maximally exposed involved worker were present when the storage facility collapsed (Accident Scenario S3), impacts would be severe. If not killed by falling accident debris, the worker could inhale lethal levels of transuranic radionuclides and hazardous chemicals.

G.3.3.2 Storage Accident Impacts for Action Alternative 2 and No Action Alternative 1

Waste which has been thermally treated to a final waste form that meets land disposal restrictions is safer to store than waste packaged to meet the planning-basis WAC. Thermally treated waste is a feature of Action Alternative 2 and No Action Alternative 1, has no VOCs, and is solidified such that radioactive material and hazardous metals are unlikely to disperse in the event of a containment breach. Radiological impacts are presented first, followed by hazardous chemical impacts. Impact estimates for thermally treated waste are presented in Tables G-31 and G-32. The subalternatives under Action Alternative 2 and No Action Alternative 1 are not evaluated separately; however, the highest impact that would occur under any of the subalternatives is presented in Tables G-31 and G-32.

Impacts to Population

The potential radiological impacts to the population surrounding any site would be highest around RFETS. Releases of radioactive materials from a container breach (Accident Scenario S1) would not be expected to result in any LCFs in the population (6×10^{-7} to 3×10^{-5}). The impacts from the catastrophic storage facility failure of Accident Scenario S3 would result in an estimated 0.8 to 10 LCFs. All major storage facility sites except INEL would be expected to have at least 1 LCF from such an event.

Table G-31
Radiological Impacts from Storage Accidents for Thermally Treated Waste (Action Alternative 2 and No Action Alternative 1)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S3 (Earthquake)	
	Person-rem or Rem	LCF	Person-rem or Rem	LCF
Population				
Hanford	2.6E-2	1E-5	18,000	9
INEL[a]	1.3E-3	6E-7	1,500	0.8
LANL[b]	1.1E-2	6E-6	4,200	2
RFETS[b]	5.2E-2	3E-5	21,000	10
SRS	3.8E-3	2E-6	2,300	1
WIPP[c]	1.4E-3	7E-7	3,600	2
MEI				
Hanford	6.6E-6	3E-9	4.5	2E-3
INEL[a]	5.4E-7	3E-10	0.65	3E-4
LANL[b]	1.5E-5	8E-9	5.6	3E-3
RFETS[b]	3.1E-6	2E-9	1.2	6E-4
SRS	2.1E-7	1E-10	0.13	6E-5
WIPP[c]	2.6E-5	1E-8	51	3E-2
Maximally Exposed Noninvolved Worker				
Hanford	6.1E-5	2E-8	41	2E-2
INEL[a]	1.4E-5	5E-9	16	6E-3
LANL[b]	4.8E-5	2E-8	17	7E-3
RFETS[b]	2.2E-5	9E-9	8.7	3E-3
SRS	3.0E-5	1E-8	18	7E-3
WIPP[c]	2.6E-5	1E-8	74	3E-2
Maximally Exposed Involved Worker				
Any Site	10	4E-3	See Text	See Text

[a] Impacts are greatest at INEL under Action Alternative 2B.
[b] CH-TRU waste is stored at LANL and RFETS only under Action Alternative 2A.
[c] CH-TRU waste is stored WIPP only under Action Alternative 2C.

Table G-32
Hazardous Chemical Carcinogenic and Noncarcinogenic Impacts from Storage Accidents for Thermally Treated Waste (Action Alternative 2 and No Action Alternative 1)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)			Accident Scenario S3 (Earthquake)	
	Cancer Incidence	Maximum IDLH-equivalent Ratio	Maximum ERPG-2 Ratio	Cancer Incidence	Maximum IDLH-equivalent Ratio
Population					
Hanford	2E-13			2E-6	
INEL	1E-14			1E-7	
LANL	9E-14	N/A	N/A	3E-7	N/A
RFETS	4E-13			4E-7	
SRS	3E-14			5E-8	
WIPP	1E-14			3E-7	
MEI					
Hanford	5E-17	2E-12	8E-6	5E-10	2E-5
INEL	4E-18	1E-13	6E-7	6E-11	2E-6
LANL	1E-16	4E-12	2E-5	3E-10	1E-5
RFETS	2E-17	8E-13	4E-6	2E-11	8E-7
SRS	2E-18	6E-14	2E-7	3E-12	9E-8
WIPP	2E-16	6E-12	2E-5	4E-9	1E-4
Maximally Exposed Noninvolved Worker					
Hanford	5E-16	2E-11	5E-5	5E-9	2E-4
INEL	1E-16	4E-12	1E-5	1E-9	5E-5
LANL	4E-16	1E-11	4E-5	1E-9	4E-5
RFETS	2E-16	6E-12	2E-5	2E-10	5E-6
SRS	2E-16	8E-12	2E-5	4E-10	1E-5
WIPP	2E-16	8E-12	2E-5	6E-9	2E-4
Maximally Exposed Involved Worker					
Any Site	5E-4	0.5	See Text	See Text	See Text

N/A = Not Applicable

The potential hazardous chemical carcinogenic impacts to populations would be very small. The population around RFETS was estimated to be the most affected of any of the exposed populations. Only hazardous metals would contribute any hazardous chemical impacts, and only cadmium and beryllium would be carcinogenic. Maximum potential carcinogenic impacts would range from 1×10^{-14} to 4×10^{-13} cancers for Accident Scenario S1 and 5×10^{-8} to 2×10^{-6} cancers for Accident Scenario S3.

Impacts to Maximally Exposed Individuals

The greatest potential radiological impacts to the MEI would be at WIPP for Accident Scenarios S1 and S3 (Action Alternative 2C only). The MEI doses for Accident Scenario S1 would range from 2×10^{-7} to 3×10^{-5} rem TEDE, with a 1×10^{-10} to 1×10^{-8} probability of an LCF. For Accident Scenario S3, MEI doses would range from 1×10^{-4} to 5×10^{-2} rem TEDE, with a 6×10^{-8} to 3×10^{-5} probability of an LCF.

The hazardous chemical impacts to the MEI would be extremely small. Carcinogenic impacts from exposure to hazardous chemicals range from a 2×10^{-18} to 2×10^{-16} probability of a cancer and a 3×10^{-12} to 4×10^{-9} probability of a cancer for Accident Scenarios S1 and S3, respectively.

Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for a noncarcinogenic impact. For Accident Scenario S1, the maximum ERPG-2 ratio is 2×10^{-5} and the maximum

IDLH-equivalent ratio is even smaller (6×10^{-12}). For Accident Scenario S3, the maximum IDLH-equivalent ratio is 1×10^{-4}. Therefore, no noncarcinogenic impacts are expected under either of the two accidents evaluated.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological impacts are greatest for the Hanford maximally exposed noninvolved worker for Accident Scenario S1 and for the WIPP maximally exposed noninvolved worker for Accident Scenario S3. Under Accident Scenario S1, radiological doses to the noninvolved worker would range from 1×10^{-5} to 6×10^{-5} rem TEDE, with a 5×10^{-9} to 2×10^{-8} probability of an LCF. Under Accident Scenario S3, the assumed storage of all waste at WIPP under Action Alternative 2C resulted in the bounding impacts. Doses under Accident Scenario S3 would range from 9 to 74 rem TEDE, with a 3×10^{-3} to 3×10^{-2} probability of an LCF.

The potential impacts to the maximally exposed noninvolved worker from exposures to hazardous chemicals as a result of the two accidents evaluated are extremely small. Under Accident Scenario S1, carcinogenic impacts are no greater than a 5×10^{-16} probability of cancer. Under Accident Scenario S3, carcinogenic impacts are no greater than a 6×10^{-9} probability of cancer. Accident Scenario S1 has a maximum ERPG-2 ratio of 5×10^{-5} and a maximum IDLH-equivalent ratio of 2×10^{-11}. Accident Scenario S3 has a maximum IDLH-equivalent ratio of 2×10^{-4}. Therefore, no noncarcinogenic impacts are expected.

Impacts to Maximally Exposed Involved Worker

Accident impacts were estimated quantitatively for the maximally exposed involved worker only under Accident Scenario S1. The drum drop was assumed to occur 3 meters (9.9 feet) from the worker, and the estimated release of the three involved containers was assumed to expand in a uniform hemisphere. The worker was assumed to inhale approximately five breaths prior to exiting to a fresh air source. For thermally treated waste, the worker would receive a dose of 10 rem TEDE, with a 4×10^{-3} probability of an LCF. The maximum first-year dose from such an intake would be 0.5 rem TEDE. A carcinogenic impact of a 5E-4 probability of cancer would be expected from hazardous metal intakes. No noncarcinogenic impacts would be expected.

If an involved worker were present when the storage facility collapsed (Accident Scenario S3), impacts would be severe. If not killed by falling accident debris, surviving workers could inhale high levels of transuranic radionuclides and hazardous chemicals.

G.3.3.3 Storage Accident Impacts for Action Alternative 3

The impacts from the potential accidental releases of waste treated by a shred and grout process are indicated in Tables G-33 through G-35. These accident analyses, which apply only to Action Alternative 3, indicate fewer impacts than those calculated for the Proposed Action because of the solidified waste form. Radiological impacts are discussed first, followed by hazardous chemical impacts. The Accident Scenario S1 radiological impacts are identical to those reported for the thermally treated waste. This is a consequence of the evaluation of 80 PE-Ci containers for each solidified waste form. It is more likely, however, that impacts from randomly selected drums under the grouted waste alternative would be less than those of randomly selected drums under thermally treated waste alternatives because actual average PE-Ci levels of grouted waste are less than those of thermally treated waste (see Table G-23).

Table G-33
Radiological Impacts from Storage Accidents for Waste Treatment by Shred and Grout (Action Alternative 3)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)	
	Rem	LCF	Rem	LCF	Rem	LCF
Population						
Hanford	2.6E-2	1E-5	5.5E-2	3E-5	18,000	9
INEL	1.3E-3	6E-7	2.7E-3	1E-6	530	0.3
LANL	1.1E-2	6E-6	2.4E-2	1E-5	4400	2
RFETS	5.2E-2	3E-5	1.1E-1	5E-5	20,000	10
SRS	3.8E-3	2E-6	8.0E-3	4E-6	2,300	1
MEI						
Hanford	6.6E-6	3E-9	1.4E-5	7E-9	4.6	2E-3
INEL	5.4E-7	3E-10	1.1E-6	6E-10	0.22	1E-4
LANL	1.5E-5	8E-9	3.2E-5	2E-8	6.0	3E-3
RFETS	3.1E-6	2E-9	6.5E-6	3E-9	1.2	6E-4
SRS	2.1E-7	1E-10	4.4E-7	2E-10	0.13	6E-5
Maximally Exposed Noninvolved Worker						
Hanford	6.1E-5	2E-8	1.3E-4	5E-8	43	2E-2
INEL	1.4E-5	5E-9	2.9E-5	1E-8	5.6	2E-3
LANL	4.8E-5	2E-8	1.0E-4	4E-8	19	7E-3
RFETS	2.2E-5	9E-9	4.6E-5	2E-8	8.6	3E-3
SRS	3.0E-5	1E-8	6.2E-5	2E-8	18	7E-3
Maximally Exposed Involved Worker						
Any Site	10	4E-3	See Text	See Text	See Text	See Text

Table G-34
Hazardous Chemical Carcinogenic Impacts from Storage Accidents for Waste Treatment by Shred and Grout (Action Alternative 3)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)	Accident Scenario S3 (Earthquake)	
	VOCs	Metals	Metals	VOCs	Metals
Population					
Hanford	5E-7	6E-14	1E-13	1E-3	2E-6
INEL	3E-8	3E-15	7E-15	4E-5	8E-8
LANL	2E-7	3E-14	6E-14	1E-4	3E-7
RFETS	1E-6	1E-13	3E-13	3E-4	6E-7
SRS	7E-8	9E-15	2E-14	2E-5	5E-8
MEI					
Hanford	1E-10	2E-17	3E-17	3E-7	6E-10
INEL	1E-11	1E-18	3E-18	2E-8	3E-11
LANL	3E-10	4E-17	8E-17	2E-7	4E-10
RFETS	6E-11	7E-18	2E-17	2E-8	3E-11
SRS	4E-12	5E-19	1E-18	1E-9	3E-12
Maximally Exposed Noninvolved Worker					
Hanford	8E-10	1E-16	3E-16	2E-6	5E-9
INEL	2E-10	3E-17	7E-17	3E-7	8E-10
LANL	6E-10	1E-16	2E-16	4E-7	1E-9
RFETS	3E-10	5E-17	1E-16	8E-8	2E-10
SRS	4E-10	7E-17	2E-16	1E-7	4E-10
Maximally Exposed Involved Worker					
Any Site	2E-7	2E-11	See Text	See Text	See Text

Table G-35
Hazardous Chemical Noncarcinogenic Impacts from Storage Accidents for Waste Treatment by Shred and Grout (Action Alternative 3)

Site	Accident Scenario S1 (Drum Puncture and Lid Failure)		Accident Scenario S2 (Drum Fire)		Accident Scenario S3 (Earthquake)
	Maximum IDLH-equivalent Ratio	Maximum ERPG-2 Ratio	Maximum IDLH-equivalent Ratio	Maximum ERPG-2 Ratio	Maximum IDLH-equivalent Ratio
MEI					
Hanford	8E-7	1E-1	1E-12	5E-6	2E-3
INEL	6E-8	9E-3	1E-13	4E-7	1E-4
LANL	2E-6	3E-1	3E-12	1E-5	1E-3
RFETS	4E-7	5E-2	6E-13	2E-6	1E-4
SRS	3E-8	4E-3	4E-14	2E-7	8E-6
Maximally Exposed Noninvolved Worker					
Hanford	5E-6	7E-1	1E-11	3E-5	1E-2
INEL	1E-6	2E-1	2E-12	7E-6	2E-3
LANL	4E-6	6E-1	9E-12	3E-5	2E-3
RFETS	2E-6	3E-1	4E-12	1E-5	5E-4
SRS	2E-6	1E-1	5E-12	2E-5	8E-4
Maximally Exposed Involved Worker					
Any Site	1E-3	7	See Text	See Text	See Text

Impacts to Population

The potential radiological impact to the population surrounding the waste storage sites would be greatest at RFETS. This result is driven by the population-weighted dispersion factor for the population southeast of the site. No LCFs would be anticipated for the RFETS or any other population as a result of Accident Scenario S1. Impact estimates range from 6×10^{-7} to 3×10^{-5} LCFs. A waste container fire (Accident Scenario S2) would also not be expected to result in any LCFs in the surrounding population of any site (1×10^{-6} to 0.1 LCFs). The catastrophic storage facility failure (Accident Scenario S3) would potentially result in up to 10 LCFs in the RFETS population and, for all sites, impacts from Accident Scenario S3 would range from 0.3 to 10 LCFs.

The potential hazardous chemical impacts would be very small; no incidences of cancer would be expected in the populations as a result of the hazardous chemical releases of the accidents analyzed. Estimates ranged from a 3×10^{-15} to 1×10^{-6} cancer incidences for Accident Scenario S1, a 2×10^{-14} to 3×10^{-13} cancer incidences for Accident Scenario S2, and a 5×10^{-8} to 1×10^{-3} cancers for Accident Scenario S3.

Impacts to Maximally Exposed Individual

The potential radiological impacts to the MEI are greatest for LANL. For Accident Scenario S1, estimated doses to the MEI would range from 5×10^{-7} to 2×10^{-5} rem TEDE, with a 1×10^{-10} to 8×10^{-9} probability of an LCF. Under Accident Scenario S2, doses would range from 4×10^{-7} to 3×10^{-5} rem TEDE, with a 2×10^{-10} to 2×10^{-8} probability of an LCF. Accident Scenario S3 would result in an estimated 0.1 to 6 rem TEDE, with a 6×10^{-5} to 3×10^{-3} probability of an LCF.

The greatest potential hazardous chemical impacts for the MEI would be at LANL under Accident Scenarios S1 and S2 and at Hanford under Accident Scenario S3. Yet, the potential impacts

overall would be very small: carcinogenic impacts would be no greater than a 3×10^{-10}, 8×10^{-17}, and 3×10^{-7} cancer incidence for Accident Scenarios S1, S2, and S3, respectively. Noncarcinogenic impact ratios of 1.0 or greater would indicate the potential for the noncarcinogenic impact. For Accident Scenario S1, the maximum ERPG-2 ratios to the MEI are 0.3 at LANL and 0.1 at Hanford, and the maximum IDLH-equivalent ratio is 2×10^{-6}. These impacts result from bounding methylene chloride inventories in the involved waste containers. For Accident Scenario S2, the maximum ERPG-2 ratio is 2×10^{-3}, and the maximum IDLH-equivalent ratio is 3×10^{-12}. Accident Scenario S3 calculations show a maximum IDLH-equivalent ratio of 2×10^{-3}. No noncarcinogenic impacts to the MEI would be expected for any of the accident scenarios evaluated.

Impacts to Maximally Exposed Noninvolved Worker

The potential radiological impacts were estimated to be greatest for the Hanford maximally exposed noninvolved worker. Under Accident Scenario S1, doses would range from 1×10^{-5} to 6×10^{-5} rem TEDE, with a 5×10^{-9} to 2×10^{-8} probability of an LCF. Under Accident Scenario S2, doses would range from 3×10^{-5} to 1×10^{-4} rem TEDE, with a 1×10^{-8} to 5×10^{-8} probability of an LCF. Accident Scenario S3 would result in the most serious radiological impacts to the noninvolved worker, with doses ranging from 6 to 43 rem TEDE and a 2×10^{-3} to 2×10^{-2} probability of an LCF.

The potential hazardous chemical impacts to the noninvolved worker would be small: carcinogenic impacts would be no greater than a 8×10^{-10}, 3×10^{-16}, and 2×10^{-6} cancer incidence for Accident Scenarios S1, S2, and S3, respectively. Noncarcinogenic impacts for Accident Scenario S1 would have a maximum ERPG-2 ratio of 0.7 at Hanford and 0.6 at LANL, which is attributable to bounding methylene chloride releases. The maximum IDLH-equivalent ratio for Accident Scenario S1 was estimated to be 5×10^{-6}. For Accident Scenario S2, the maximum ERPG-2 ratio is 3×10^{-5}, and the maximum IDLH-equivalent ratio is 1×10^{-11}. For Accident Scenario S3, the maximum IDLH-equivalent ratio is 1×10^{-2}. Therefore, no noncarcinogenic impacts to the noninvolved worker would be expected from the hazardous chemical releases for the accidents evaluated.

Impacts to Maximally Exposed Involved Worker

Accident impacts were estimated quantitatively for the maximally exposed involved worker only for Accident Scenario S1. The drum drop was assumed to occur 3 meters (9.9 feet) from the worker and the estimated release of the three involved containers was assumed to expand in a uniform hemisphere. The worker was assumed to inhale approximately five breaths prior to exiting to a fresh air source. For waste packaged to meet the planning-basis WAC, the worker would receive a dose of 10 rem TEDE, with a 4×10^{-3} probability of an LCF. The maximum first-year dose from such an intake would be 0.5 rem. Carcinogenic impacts from VOC and hazardous metal intakes would be 2×10^{-7} and 2×10^{-11} probability of a cancer incidence, respectively. There could be reversible impacts to the involved worker as a result of carbon tetrachloride releases (ERPG-1 ratio of 3). Exposure to bounding methylene chloride releases from Accident Scenario S1 could result in serious impacts (ERPG-3 ratio of 3).

If an involved worker were located next to a drum fire when it erupted (Accident Scenario S2), impacts would be great. However, the probability that this scenario would occur is minute because

an action by the worker does not initiate the accident. The smoke would be apparent and the worker can be presumed to exit the facility immediately.

If an involved worker were present when the storage facility collapsed (Accident Scenario S3), impacts would be severe. If not killed by falling accident debris, surviving workers could inhale high levels of transuranic radionuclides and hazardous chemicals.

G.4 WIPP DISPOSAL ACCIDENT SCENARIOS

This section describes the accident scenarios evaluated for disposal operations at the WIPP site. Scenarios include accidents previously evaluated in *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990), and, for the roof fall (Accident Scenario W7), in the SAR (DOE 1995b). Table G-36 presents the accident scenarios evaluated in this section with their specified SEIS-II identifying numbers and, for those scenarios that were also evaluated in SEIS-I, the corresponding SEIS-I identifier.

Table G-36
WIPP Disposal Accident Scenarios

SEIS-II Accident Scenario	Accident Description	Waste Type	Prior Analysis Reference
W1	Container Drop and Lid Seal Failure in the Waste Handling Building	CH-TRU	SEIS-I C2
W2	Container Puncture, Drop and Lid Seal Failure in the Waste Handling Building	CH-TRU	SEIS-I C3
W3	Container Drop and Lid Seal Failure in the Underground	CH-TRU	SEIS-I C4
W4	Container Puncture, Drop and Lid Seal Failure in the Underground	CH-TRU	SEIS-I C6
W5	Container Fire in the Underground	CH-TRU	SEIS-I C10
W6	Failure of the Waste Shaft Hoist	CH-TRU RH-TRU	SEIS-I C8 none [a]
W7	Roof Fall in a Disposal Room in the Underground	CH-TRU	SAR CH 11
W8	RH-TRU Waste Canister Breach in the Waste Handling Building	RH-TRU	SEIS-I R4

[a] Accident R5 in SEIS-I but no analysis was conducted.

Additional information on the accident scenarios is provided below. The base case descriptions assume that the waste is packaged to meet the minimum planning-basis WAC requirements. Additional cases are added to describe accidents for thermally treated waste (Action Alternative 2 and No Action Alternative 1) and waste treated by the shred and grout process (Action Alternative 3). Accident scenarios involving CH-TRU waste treated to planning-basis WAC requirements (Proposed Action and Action Alternative 1) were evaluated for both waste drums and standard waste boxes, whereas thermally treated waste and grout waste were assumed to be only in drums. Accident evaluations for all RH-TRU waste assumed that waste would be packaged in drums inside RH-TRU waste canisters.

G.4.1 Inventory

Waste container inventories for radionuclides, hazardous metals, and VOCs are the same as the stored waste inventories in Section G.3.1. The quantity of any potentially hazardous constituents in waste to be disposed of at WIPP is limited by the planning-basis WAC. Radionuclides have greater potential impact than hazardous chemicals; therefore, CH-TRU waste drums may contain no more than 80 PE-Ci, CH-TRU waste standard waste boxes may contain no more than 130 PE-Ci, and RH-TRU waste canisters may contain no more than 1,000 PE-Ci. Radionuclide activities at these limits were assumed to be present in waste containers evaluated for all accidents except the roof fall (Accident Scenario W6). Because of the large number of drums affected, the average PE-Ci content was used. Table G-37 shows the average radionuclide content of waste at WIPP, which are the same values shown in Tables G-23 and G-24. Drum headspace concentrations of VOCs would be are the same as those shown in Table G-25, and drum hazardous metal contents would remain the same as those shown in see Table G-27.

Table G-37
Average WIPP Radionuclide Content of CH-TRU Waste and RH-TRU Waste (PE-Ci per waste container)[a]

Proposed Action		Action Alternative 1		Action Alternative 2		Action Alternative 3	
CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste	CH-TRU Waste	RH-TRU Waste
3.5	0.3	2.9	3.0	7.7	8.6	2.5	2.5

[a] CH-TRU waste content is measured by PE-Ci per drum-equivalent (or 0.208 cubic meters). RH-TRU waste content is measured by PE-Ci per canister, each containing three drum equivalents.

G.4.2 WIPP Disposal Accident Analysis

This section presents the accident analyses and estimated source terms for each of the eight WIPP disposal accident scenarios. TRU waste may be stored in either drums or standard waste boxes when treated to the planning-basis WAC, but because of the greater density and mass of these waste forms, would only be in drums for thermally treated or waste treated by a shred and grout process. Initial analyses showed that potential impacts from accidents involving standard waste boxes could be about 60 percent higher than the same accident involving drums. However, only impacts from waste in drums was analyzed in detail because drums were assumed to contain the majority of waste disposed of underground and are also expected to contain higher concentrations of radionuclides.

Estimates of particulate radionuclides and hazardous metals released to the atmosphere outside a facility (the accident source term for members of the public and maximally exposed noninvolved workers) do not consider HEPA filtration of exhaust streams. The Waste Handling Building has continuous HEPA filtration. Therefore, impacts reported for the Waste Handling Building particulate releases (i.e., radioactive materials and hazardous metals) may be overestimated by a factor of one thousand or more, assuming a filtration efficiency of at least 99.9 percent. The underground effluent is not normally HEPA-filtered; salt accumulation on the HEPA filter from filtration of the ambient underground air would degrade the filter. A system is in place that would allow air to be routed through HEPA filter banks in the event that radioactive material is detected in the underground exhaust effluent. Recent investigations by the Environmental Evaluation Group

(EEG) (Bartlett 1993 and 1996) have questioned the ability of the detection system to operate appropriately because of salt build-up on the detection probe. Therefore, excluding consideration of HEPA filtration for underground accidents would encompass potential impacts in the event that the detector fails to function properly. If the underground releases are HEPA-filtered, the impact estimates from particulate releases would be reduced by a factor of as much as one million.

The entire VOC headspace volume was assumed to be released as a result of container failures for each accident scenario. An average of 0.147 cubic meters (5 cubic feet) of headspace was assumed per drum (DOE 1990). The same headspace volume was assumed for waste treated to planning-basis WAC and for grouted waste. Because the packing efficiency should improve as a result of the packaging and uniform waste matrix, this would be a conservative assumption for grouted waste under Action Alternative 3. For releases from the underground through the Exhaust Filter Building to the atmosphere, it was assumed that none of the VOCs would deposit on interior walls, exhaust ventilation walls, or the HEPA filtration system.

Descriptions of each of the WIPP accident scenarios for each of the three waste forms that may be disposed of underground are presented below.

Accident Scenario W1 - Container Drop and Lid Seal Failure in the Waste Handling Building

Under this scenario, a package is dropped from a forklift (either a seven-pack of CH-TRU waste drums or a standard waste box) while being handled in the Waste Handling Building. Because the waste containers are Type A packages, per U.S. Nuclear Regulatory Commission (NRC) requirements, they are designed to withstand a 4-foot (1-meter) drop onto an unyielding surface without damage. However, because the vertical lift can exceed this designed rating, it was assumed that the container drop and subsequent crushing causes the lid of a single container to be knocked off. No inner plastic liner was assumed to be present. A fraction of the respirably-sized particulates in the drum were assumed to be suspended inside the drum during the fall and released when the lid failed. Also, the contents may be released and the respirable particles resuspended from this material. Facility HEPA filtration was not considered for releases to the atmosphere. This method was applied to the quantities of particulate radionuclides and hazardous metals (lead, mercury, beryllium, and cadmium) in the waste.

All VOCs present in the container headspace were assumed to be released, with a total release fraction equal to one. Calculation of material released to the environment assumed that no adsorption, absorption, or plateout onto internal building surfaces would occur.

Workers in the immediate vicinity of the accident were assumed to notice the container breach and exit the work area. Each worker would inhale 5.6 liters (1.5 gallons) of contaminated air before exiting. The volume is about four average breaths at 1.25 liters (0.3 gallons) inhaled per breath for an average male during light activity [ICRP 1991]) and is equivalent to the entire lung air volume of an average adult male. The concentration of hazardous chemicals in the air that the worker inhales was determined by assuming that the worker is located 3 meters (9.9 feet) from the airborne release and the release expands in a uniform hemisphere from ground level.

Case W1a: Waste Treated to Planning-Basis WAC

Either a seven-pack of CH-TRU waste drums or a standard waste box would be handled in the Waste Handling Building. Twenty-five percent of the container contents were assumed to spill

(DOE 1990). The fraction of the spilled contents that would become airborne was assumed to be 0.001 and the respirable fraction was assumed to be 0.1, based on material packaged in a drum that opens due to impact with the floor or falling debris (DOE 1994a). This value is the same as the DOE 1994 value used for suspension of powder in a can due to debris impact. The total respirable release fraction for particulates would be 2.5×10^{-5}.

Case W1b: Thermally Treated Waste

Only drums would be handled in this accident scenario. The waste was assumed to be a solid vitrified mass, so that only a small amount of particulate material would be released. A respirable resuspension fraction of 1×10^{-5} was used (DOE 1994a), assuming a brittle fracture of the waste mass during the fall. Twenty-five percent of the resuspended material was assumed to be released from the container, so the total respirable release fraction would be 2.5×10^{-6} of the radionuclides and hazardous metals in the container. No VOCs would be present in the thermally treated waste.

Case W1c: Waste Treated by a Shred and Grout Process

Only drums would be handled in this accident scenario. The grouted waste is a solid concrete-like mass. A respirable resuspension fraction value of 1×10^{-5} was used (DOE 1994a), assuming brittle fracture of the waste mass during the fall. Twenty-five percent of the respirable resuspended material was assumed to be released from the container, resulting in a total respirable release fraction of 2.5×10^{-6} (the same as for thermally treated waste).

Accident Scenario W2 - Container Puncture, Drop, and Lid Failure in the Waste Handling Building

A Waste Handling Building forklift operator error causes a forklift to strike and puncture either drums or a standard waste box. An additional drum or standard waste box is knocked off and the lid fails. Because the waste containers are Type A packages, per NRC requirements, they are designed to withstand a 4-foot (1-meter) drop onto an unyielding surface without damage. However, because the vertical lift can exceed this designed rating, it was assumed that the container drop and subsequent crushing causes the lid of a single container to be knocked off. No inner plastic liner was assumed to be present. A fraction of the respirably-sized particulates in the drum was assumed to be suspended inside the drum during the fall. A fraction of these would then be released when the lid failed, or the contents may be released and respirable particles resuspended from this material. Facility HEPA filtration was not considered for releases to the atmosphere. This method was applied to the quantities of particulate radionuclides and hazardous metals (lead, mercury, beryllium, and cadmium) in the waste.

All VOCs present in the container headspace were assumed to be released, with total release fraction equal to one. Calculation of material released to the environment assumed that no adsorption, absorption, or plateout onto internal building surfaces would occur.

Involved worker intakes were calculated in the same manner as Accident Scenario W1.

Case W2a: Waste Treated to Planning-Basis WAC

Both waste drum and standard waste box accident scenarios were evaluated. For the drum scenario, an error by a Waste Handling Building forklift operator causes a forklift to strike and puncture two drums. As a result of the impact, a third drum falls from the stack and its lid is

knocked off upon impact with the floor. It was assumed that 10 percent of the waste spills out of the two punctured drums and 25 percent spills out of the lidless drum. For the standard waste box scenario, one standard waste box is punctured, and the one stacked above it falls to the ground. The lid seal of the fallen standard waste box is assumed to fail as a result of the impact and 25 percent of the contents are released. As in Accident Scenario W1 for both drums and standard waste boxes, 0.001 of the spilled fraction was assumed to be resuspended in the room air and 0.1 of this resuspended fraction was assumed to be respirable.

Case W2b: Thermally Treated Waste

Only drums were assumed to be used under this treatment option. Impacts from particulate releases or Case W2b would be identical to those of Case W1b, with material released only from the drum with lid failure. No releases of particulates from the punctured drums would occur. No VOCs would be present in thermally treated waste.

Case W2c: Waste Treated by Shred and Grout Process

Only drums were assumed to be used under this treatment option. Impacts from particulate releases for Case W2c would be identical to those of Case W1c, with material released only from the drum with lid failure. No particulate releases from the punctured containers would occur. Headspace VOCs from all three of the damaged drums were assumed to be released, so VOC-related impacts would be three times higher than for Case W1c.

Accident Scenario W3 - Container Drop and Lid Seal Failure in the Underground

Accident Scenario W3 and its container releases are identical to those described for Accident Scenario W1 except that the accident occurs underground. Particulate radionuclide and hazardous metal releases to the atmosphere from the underground ventilation system would be reduced 20 percent as compared to Waste Handling Building releases because of particle depletion and plateout over the long distance between the underground location of the incident and the aboveground exhaust point to release at the Exhaust Filter Building (DOE 1990).

All VOCs present in the container headspace were assumed to be released, with a total release fraction equal to one. Calculation of material released to the environment assumed that no adsorption, absorption or plateout onto internal building surfaces would occur.

Involved worker intakes underground were calculated in the same manner as for Accident Scenario W1.

Case W3a: Waste Treated to Planning-Basis WAC

Case W3a is identical to Case W1a except that particulate releases to the atmosphere would be reduced 20 percent due to particle depletion and plateout.

Case W3b: Thermally Treated Waste

Case W3b is identical to Case W1b except that particulate releases to the atmosphere would be reduced 20 percent due to particle depletion and plateout.

Case W3c: Waste Treated by a Shred and Grout Process

Case W3c is identical to Case W1c except that particulate releases to the atmosphere would be reduced 20 percent due to particle depletion and plateout.

Accident Scenario W4 - Container Puncture, Drop, and Lid Seal Failure in the Underground

Accident Scenario W4 and its container releases are identical to those described for Accident Scenario W2 except that the accident occurs underground. Particulate radionuclide and hazardous metal releases to the atmosphere from the underground ventilation system would be reduced 20 percent as compared to Waste Handling Building releases because of particle depletion and plateout over the long distance between the underground location of the incident and the aboveground exhaust point to release at the Exhaust Filter Building (DOE 1990).

All VOCs present in the container headspace were assumed to be released with a total release fraction equal to one. Calculation of VOCs released to the environment assumed that no adsorption, absorption, or plateout onto internal building surfaces would occur.

Involved worker intakes underground were calculated in the same manner as for Accident Scenario W1.

Case W4a: Waste Treated to Planning-Basis WAC

Case W4a is identical to Case W2a except that particulate releases to the atmosphere would be reduced 20 percent due to particle depletion and plateout.

Case W4b: Thermally Treated Waste

Case W4b is identical to Case W2b except that particulate releases to the atmosphere would be reduced 20 percent due to particle depletion and plateout.

Case W4c: Grouted Waste

Case W4c is identical to Case W2c except that particulate releases to the atmosphere would be reduced 20 percent due to particle depletion and plateout.

Accident Scenario W5 - Container Fire in the Underground

A fire was assumed to start inside a closed waste container and involve only the single container. Only a fire in the underground was evaluated because of the relatively short period of time any one drum would be present in the Waste Handling Building. Released particulates would be subject to a high amount of deposition (0.8) due to the heated aerosol reacting with the relatively cool surfaces within the facility (DOE 1990). The VOCs in the waste container were assumed to be consumed by the fire. Because an individual worker's actions do not initiate the accident, involved worker exposures were not calculated.

The EEG investigated the history of hazardous waste drum fires, explosions, and other pressurizations at DOE facilities (Silva 1991). The incidents were attributed to the discharge of static electricity, spontaneous ignition of pyrophoric materials, and reactions involving nitric acid. Other contributing circumstances included the drums being painted black, exposure to direct

sunlight, and improper packaging material. At WIPP, such incidents would be limited by the fact that containers would be painted white, would not be exposed to direct sunlight, and would be certified to the planning-basis WAC, which limits pyrophoric and reactive compounds in the waste containers.

Case W5a: Waste Treated to Planning-Basis WAC

Waste drum and standard waste box accident scenarios were evaluated. It was assumed that 5×10^{-4} of the radioactive and hazardous metals would be resuspended as respirable particles, a conservative value of the fraction of respirable particles expected from the burning of either combustible or noncombustible materials (DOE 1994a).

Case W5b: Thermally Treated Waste

There would be no combustible materials in the waste after thermal treatment, so a fire would be an unlikely scenario.

Case W5c: Waste Treated by a Shred and Grout Process

Only drums were assumed to be used under this treatment option. Although the waste would be uniformly mixed within a noncombustible grout matrix, accident impacts were calculated for this scenario. Twenty-two percent of a concrete mass would be transformed to a powder as a result of fire temperatures of at least 650 degrees Celsius (1,200 degrees Fahrenheit) (DOE 1994a); therefore, it was assumed that 22 percent of the grouted waste would be transformed to a powder as a result of a container fire. A respirable resuspension fraction of 6.0×10^{-5} for particulates was used (DOE 1994a), which reflects the fraction of heated powder resuspended by the vapor flux generated by an open fire.

Accident Scenario W6 - Failure of the Waste Shaft Hoist

The waste hoist braking system was assumed to fail when the hoist was fully loaded and at the top of the shaft. The hoist was assumed to fall 655 meters (2,150 feet) to the bottom of the waste hoist shaft. Depending on its physical form, material dropped from great heights will generally exhibit plastic properties or will shatter on impact. The respirable fraction differs for each type of material; for example, material that shatters produces the greatest quantity of respirable-sized articles. The maximum estimated respirable resuspended particulate fraction for a brittle material that drops 655 meters (2,150 feet) is 3×10^{-3} (DOE 1994a). The waste hoist was assumed to be fully loaded with either 28 drums or four standard waste boxes containing CH-TRU waste or one RH-TRU waste canister.

Releases of particulate radionuclide and hazardous metal releases to the atmosphere from the underground ventilation system would be reduced 20 percent because of particle depletion and plateout over the long distance between the underground location of the incident and the aboveground exhaust point to release at the Exhaust Filter Building (DOE 1990). All headspace VOCs in CH-TRU and RH-TRU waste were assumed to be released, with a total release fraction equal to one.

This accident would require simultaneous failure of six hoisting cables or loss of power and failure of the hoist braking system. The probability of failure of the waste shaft hoist has been investigated by EEG (Greenfield and Sargent 1995). The most critical element for this accident was determined

to be failure of the hoist hydraulic brake system. The 95th percentile annual probability of this incident occurring is 4.5×10^{-7}, updating the previous 1×10^{-4} to 1×10^{-6} annual probability estimate, which resulted from the absence of preoperational checks of the hoist system at the start of each shift in WIPP operating procedures. Because of this low probability, this accident scenario is the comparable to of the beyond-design-basis earthquakes evaluated for treatment and storage.

Case W6a: Waste Treated to Planning-Basis WAC

Both waste drums and standard waste boxes containing CH-TRU waste were evaluated. All radionuclides and hazardous metals were assumed to be released from half of the waste containers upon impact and to completely escape the accident debris for a release fraction of one. Material in the other half of the CH-TRU waste containers involved in the accident were assumed to have an overall release fraction of 0.1, with 90 percent of the material either not released or contained within the accident debris. The particulate resuspension fraction for all of the released radionuclides and hazardous metals was assumed to be 1×10^{-3}, and all of this material was assumed to be of respirable size.

Under the same accident scenario, 70 percent of the radionuclides and hazardous metals in RH-TRU waste would be released, with 30 percent contained by the accident debris at the bottom of the shaft. The released radionuclides and hazardous metals were assumed to have a resuspension fraction of 5.5×10^{-4} (half of the waste having a resuspension fraction of 1×10^{-4} and the other half of the waste having a resuspension fraction of 1×10^{-3}).

Case W6b: Thermally Treated Waste

Only waste drums were assumed to be used under this treatment option. Vitrified CH-TRU waste would shatter on impact and all radionuclides and hazardous metals would be released. The bounding respirable resuspension fraction of 3×10^{-3} for a shattering material was assumed. No VOCs would be present in thermally treated waste.

Under the same accident scenario 70 percent of radionuclides and hazardous metals in RH-TRU waste would be released, with 30 percent contained by the accident debris at the bottom of the shaft. The released radionuclides and hazardous metals were assumed to have the bounding respirable resuspension fraction of 3×10^{-3}. No VOCs would be present in thermally treated waste.

Case W6c: Waste Treated by a Shred and Grout Process

For particulate radionuclides and hazardous metals in CH-TRU and RH-TRU waste, the analysis would be identical to that of Case W6b, assuming the grouted waste would shatter on impact. Grouted waste containing VOCs and the entire headspace volume were assumed to be released.

Accident Scenario W7 - Roof Fall in a Disposal Room in the Underground

A portion of the roof in a disposal room of a waste panel was assumed to fall during waste emplacement. Roofs are more likely to fall when panels have been open a long time. This accident would have a higher probability of occurring in Panel 1, because it would have been open the longest.

The CH-TRU waste containers in disposal rooms would be stacked three high with a maximum of five groups of seven-packs across the width of the room. The drums directly under the fallen roof

section were assumed to be crushed. The crushed drums shift and deform adjoining waste stacks, and several of the stacks at the working end of the emplacement operations would fall. The roof collapse was assumed to occur when a disposal room was more than half full and the roof section that falls was assumed to crush the equivalent of half of a disposal room of drums (approximately 2,100). All five seven-packs (35 drums total) on the upper level of the working end of the stack were assumed to fall to the panel floor. Lid failure was assumed for half of the drums in the seven-packs (18 drums) as a result of the drop. The seven packs in the bottom two levels of the stack are assumed to shift and deform but not fall or breach. The RH-TRU waste, placed in the panel walls, would not be affected by a roof fall. The particulates in crushed drums were assumed to be contained by the fallen roof section and not be released.

The fallen roof section was assumed not to be thick enough to halt the ventilation flow through the disposal room and panel. Releases of particulate radionuclide and hazardous metal releases to the atmosphere from the underground ventilation system are reduced 20 percent because of particle depletion and plateout over the long distance between the underground location of the incident and the aboveground exhaust point to release at the Exhaust Filter Building (DOE 1990). No facility HEPA filtration was considered.

All VOCs in the crushed container headspace were assumed to be released, with a total release fraction equal to one.

Case W7a: Treatment of waste to Planning-Basis WAC

Drum and standard waste box accident scenarios were evaluated, with either 18 drums or five standard waste boxes breached. Twenty-five percent of the waste was assumed to spill out of the fallen drums, with a respirable resuspension fraction of 1×10^{-4} of the radioactive materials and hazardous metals.

Case W7b: Thermally Treated Waste

Only drums would be emplaced, and only about half of the volume of CH-TRU waste of the other alternatives can be disposed of in each panel because of thermal power limitations. Therefore, a smaller total volume of waste containers would be impacted by the roof fall. This assumption does not affect accident impacts because the number of breached containers at the working end of the stack was assumed to be the same as described above, with 18 drums breached. A respirable resuspension fraction of 1×10^{-5} was used (DOE 1994a), assuming a brittle fracture of the waste mass during the fall. Twenty-five percent of the resuspended material was assumed to be released from the container, so the total respirable release fraction would be 2.5×10^{-6} of the radionuclides and hazardous metals in the container. No VOCs would be present in the thermally treated waste.

Case W7c: Waste Treated by a Shred and Grout Process

Only drums would be emplaced, and 18 drums were assumed to breach. A respirable resuspension fraction value of 1×10^{-5} was used (DOE 1994a), assuming brittle fracture of the waste mass during the fall. Twenty-five percent of the respirable resuspended material was assumed to be released from the container, resulting in a total respirable release fraction of 2.5×10^{-6}, the same as for thermally treated waste. All container headspace VOCs were assumed to be released.

Accident Scenario W8 - RH-TRU Waste Canister Breach in the Waste Handling Building

This scenario is similar to one evaluated in SEIS-I (DOE 1990). An RH-TRU waste canister is dropped into the transfer cell from the hot cell (a distance of 11 meters [36 feet]) when a grapple fails. It was assumed that the canister is breached in the fall. No facility HEPA filtration was considered.

All VOCs in the container headspace were assumed to be released, with a total release fraction of 1.0.

No impacts to involved workers were calculated because the accident is assumed to occur inside the shielded transfer cell.

Case W8a: Waste Treated to Planning-Basis WAC

One percent of the waste spills from the canister and 1×10^{-4} of the spilled material is resuspended in the room air.

Case W8b: Thermally Treated Waste

No particulates would be spilled from the breached container because of the uniformly mixed waste form. No VOCs would be present in the thermally treated waste.

Case W8c: Waste Treated by a Shred and Grout Process

No particulates would be spilled from the breached container because of the consolidated waste form. All of the headspace VOCs would be released.

The radionuclide and hazardous metal source term for each accident was calculated using Equation G-6, shown below. The source term, S, was specified in terms of the number of respirable PE-Ci that would be released for radionuclides, and as the number of kilograms released for hazardous metals. For many of the accidents, use of this equation and these parameters may be conservative for lead or mercury, which can be highly malleable and less subject to particulate rupture as a result of accident impact shocks.

$$S = (N)(Q)(f_{rel})(f_{resp})(f_{air}) \qquad \text{(Equation G-6)}$$

where

S = source term (PE-Ci or kilograms)

N = number of containers involved

Q = radionuclide or hazardous material inventory of a waste container (PE-Ci or kilograms)

f_{rel} = fraction of the contents released from the container

f_{resp} = fraction of released contents that becomes airborne as a respirable-sized particle

f_{air} = fraction of released contents remaining in the air stream after deposition and plateout onto drift and shaft walls following underground releases

Parameter values are described in the accident scenario descriptions. The parameter values used to estimate the radionuclide and hazardous metal source terms are presented in Table G-38 for the Proposed Action and Action Alternative 1 and in Table G-39 for Action Alternatives 2 and 3. In Table G-38, parameter values for both drums and standard waste boxes are presented although impact estimates are presented in Section G.4.3 only for waste in drums. Impacts may be slightly higher for standard waste box accident scenarios, but impacts for waste stored in drums are a more appropriate comparison for impacts of Action Alternatives 2 and 3.

The radionuclide accident source term (in PE-Ci) following release from the stack is presented in Table G-40. The quantity of radionuclides that would be inhaled by an involved worker, also in PE-Ci, is presented in Table G-41. No analyses were performed to estimate impacts to involved workers for Accident Scenarios W5, W6, W7, and W8, because impacts could range from negligible to catastrophic. The range of impacts is discussed further in Section G.4.3.

Table G-38
Accident Analysis Parameters for Waste Treated to Planning-Basis WAC for the Proposed Action and Action Alternative 1

SEIS-II Accident Scenario	Accident Description	Parameter Values			
		N	f_{rel}	f_{resp}	f_{air}
W1	Drop, Lid Failure in Waste Handling Building	D: 1 S: 1	0.25	1E-4	N/A
W2	Drop, Puncture Lid Failure in Waste Handling Building	D: 3 S: 2	D: 2 @ 0.1 1 @ 0.25 S: 1 @ 0.1 1 @ 0.25	1E-4	N/A
W3	Drop, Lid Failure in Underground	D: 1 S: 1	0.25	1E-4	0.8
W4	Drop, Puncture, Lid Failure in Underground	D: 3 S: 2	D: 2 @ 0.1 1 @ 0.25 S: 1 @ 0.1 1 @ 0.25	1E-4	0.8
W5	Container Fire	D: 1 S: 1	1	5E-4	0.2
W6	Hoist Failure CH-TRU Waste	D: 28 S: 4	D: 14 @ 1.0 14 @ 0.1 S: 2 @ 1.0 2 @ 0.1	1E-3	0.8
	RH-TRU Waste	1	0.7	5.5E-4	0.8
W7	Roof Fall	D: 18 S: 5	0.25	1E-4	0.8
W8	RH-TRU Waste Canister Breach	RH: 1	0.01	1E-4	0.8

[a] D = drum, S = standard waste box, RH = RH-TRU waste canister

N/A = Not Applicable

Table G-39
Accident Analysis Parameters for Thermally Treated and Grouted Waste for the Action Alternative 2 Subalternatives and Action Alternative 3

SEIS-II Accident Scenario	Accident Description	Parameter			
		N	f_{rel}	f_{resp}	f_{air}
W1	Drop, Lid Failure in Waste Handling Building	1	0.25	1E-5	N/A
W2	Drop, Puncture Lid Failure in Waste Handling Building	3	1 @ 0.25 2 @ 0	1E-5	N/A
W3	Drop, Lid Failure in Underground	1	0.25	1E-5	0.8
W4	Drop, Puncture, Lid Failure in Underground	3	1 @ 0.25 2 @ 0	1E-5	0.8
W5	Container Fire	1	0.22	6E-5	0.2
W6	Hoist Failure CH-TRU Waste RH-TRU Waste	 28 1	 1 0.7	 3E-3 3E-3	 0.8 0.8
W7	Roof Fall	18	0.25	1E-5	0.8
W8	RH-TRU Waste Canister Breach	1	0	N/A	N/A

[a] Only applies to grouted waste under Action Alternative 3.

N/A = Not Applicable

Table G-40
Source Terms for Off-site Releases from WIPP Disposal Accidents (in PE-Ci)

SEIS-II Accident Scenario	Accident Description	Proposed Action	Action Alternative 1	Action Alternative 2 Subalternatives	Action Alternative 3
W1	Drop, Lid Failure in Waste Handling Building	2E-3	2E-3	2E-4	2E-4
W2	Drop, Puncture Lid Failure in Waste Handling Building	3.6E-3	3.6E-3	2E-4	2E-4
W3	Drop, Lid Failure in Underground	1.6E-3	1.6E-3	2E-4	2E-4
W4	Drop, Puncture, Lid Failure in Underground	2.9E-3	2.9E-3	2E-4	2E-4
W5	Container Fire	8E-3	8E-3	N/A	2E-4
W6	Hoist Failure CH-TRU Waste RH-TRU Waste	 1.0 0.3	 1.0 0.3	 5.4 1.7	 5.4 1.7
W7	Roof Fall	0.036	0.036	4E-3	4E-3
W8	RH-TRU Waste Canister Breach	0.001	0.001	0	0

Table G-41
Involved Worker Intakes from WIPP Disposal Accidents (in PE-Ci)

SEIS-II Accident Scenario	Accident Description	Proposed Action	Action Alternative 1	Action Alternative 2 Subalternatives	Action Alternative 3
W1	Drop, Lid Failure in Waste Handling Building	2E-7	2E-7	2E-8	2E-8
W2	Drop, Puncture Lid Failure in Waste Handling Building	4E-7	4E-7	2E-8	2E-8
W3	Drop, Lid Failure in Underground	2E-7	2E-7	2E-8	2E-8
W4	Drop, Puncture, Lid Failure in Underground	4E-7	4E-7	2E-8	2E-8

G.4.3 Impacts of WIPP Disposal Accidents

Impacts from WIPP disposal accidents were calculated for the exposed off-site population around WIPP, the MEI, the maximally exposed noninvolved worker, and the maximally exposed involved worker. Acute releases were assumed to be dispersed in one direction, so population impacts were estimated for a single, maximally exposed 22.5-degree sector (out to 80 kilometers [50 miles]) and not for the entire 80-kilometer (50-mile) region population. Population-weighted atmospheric dispersion values were calculated and used to determine the maximally impacted sector, considering both the change in air concentration over distance and the population distribution in the sector. The population west of the WIPP site, including the nearest population center at Carlsbad, New Mexico, would receive the greatest potential impact from an accidental WIPP release. The MEI was assumed to be at the WIPP fenceline location where the atmospheric dispersion would be minimized, resulting in maximum air concentrations. This location is 300 meters (1,000 feet) south of the Exhaust Filter Building at the Exclusive Use Area boundary. The same location was used to calculate impacts to the maximally exposed noninvolved worker, because this would be the point of highest impact of any on-site location. The maximally exposed worker is the waste-handler who initiates the accident. All accident evaluations assumed the noninvolved worker, MEI, and population remained in the plume during its entire time of passage. Only impacts from the inhalation pathway were considered.

The estimated annual frequencies of occurrence for WIPP disposal accidents were taken from DOE (1995b) (Accident Scenarios W1, W2, W3, W4, W5, and W7) and Greenfield and Sargent (1995) (Accident Scenario W6) and are presented in Table G-42. Accident Scenario W8, the RH-TRU waste canister breach accident has been estimated to have an annual frequency of occurrence to range from 1×10^{-4} to 1×10^{-6}. When a frequency range was identified, the highest value (i.e., the greater frequency) was used in the analysis. The Accident Scenario W6 annual frequency of occurrence is the 95th percentile value of EEG Report 59 (Greenfield and Sargent 1995). Occurrence frequencies for the Action Alternative 2 subalternatives were assumed to be half of the values for waste treated to planning-basis WAC and waste treated by a shred and grout process because waste would not need to be stacked as high in the underground, thereby reducing the probability of lid failure in the event of a container drop. The mass of waste containers under the Action Alternative 2 subalternatives is potentially at the maximum drum limit of 450 kilograms (1,000 pounds). This may affect the likelihood of an accident, but this effect was not considered.

Table G-42
Annual Frequencies of Occurrence for WIPP Disposal Accidents

SEIS-II Accident Scenario	Accident Description	Proposed Action	Action Alternative 1	Action Alternative 2 Subalternatives	Action Alternative 3
W1	Drop, Lid Failure in Waste Handling Building	0.1	0.1	0.05	0.1
W2	Drop, Puncture Lid Failure in Waste Handling Building	0.1	0.1	5E-3	0.1
W3	Drop, Lid Failure in Underground	0.1	0.1	0.05	0.1
W4	Drop, Puncture, Lid Failure in Underground	0.01	0.01	5E-3	0.01
W5	Container Fire	1E-4	1E-4	N/A	1E-4
W6	Hoist Failure	4.5E-7	4.5E-7	2.3E-7	4.5E-7
W7	Roof Fall	0.01[a] 9E-7[b]	0.01[a] 9E-7[b]	5E-3[a] 4.5E-7[b]	0.01[a] 9E-7[b]
W8	RH-TRU Waste Canister Breach	1E-4 to 1E-6	1E-4 to 1E-6	5E-5 to 5E-7	1E-4 to 1E-6

[a] Panel 1
[b] Other panels

G.4.3.1 Accident Impacts for Proposed Action and Action Alternative 1

Impacts of accidents under the Proposed Action and Action Alternative 1 would be the same because waste is treated to planning-basis WAC. Potential radiological impacts would predominate for all accidents. There would be no expected cancer incidence in the exposed population and very low probabilities of cancer to exposed individuals from VOCs and hazardous metals for all accidents. Only one accident, the hoist failure (Accident Scenario W6), would result in radiation-related LCFs in the exposed population around WIPP. Up to five LCFs could occur in exposed sector-population from a hoist failure involving CH-TRU waste, and one LCF could occur from a hoist failure involving RH-TRU waste. The probability of an LCF to the MEI would be 0.07 (7 percent chance) for the CH-TRU waste accident scenario, and 0.02 (2 percent chance) for the RH-TRU waste accident scenario. Table G-43 presents the radiological impacts from WIPP disposal accidents under the Proposed Action and Action Alternative 1.

Potential carcinogenic impacts from exposure to VOCs and hazardous metals released during WIPP disposal accidents are presented in Table G-44. As noted above, no incidences of cancer would be expected in the exposed population, and impacts to individuals would be very low.

Potential noncarcinogenic impacts from exposure to VOCs and hazardous metals released during an accident are presented in Table G-45. No noncarcinogenic health effects would be expected. The majority of the small noncarcinogenic impact is from tetrachloroethene and 1,1,2,2-tetrachloroethane releases.

Table G-43
Radiological Impacts of WIPP Disposal Accidents Under the Proposed Action and Action Alternative 1

SEIS-II Accident Scenario	Accident Description	Population (person-rem, LCFs)	MEI (rem, probability of LCF)	Maximally Exposed Noninvolved Worker (rem, probability of LCF)	Maximally Exposed Involved Worker (rem, probability of LCF)
W1	Drop, Lid Failure in Waste Handling Building	17 9E-3	0.26 1E-4	0.26 1E-4	100 0.04
W2	Drop, Puncture Lid Failure in Waste Handling Building	31 0.02	0.47 2E-4	0.47 2E-4	180 0.07
W3	Drop, Lid Failure in Underground	14 7E-3	0.21 1E-4	0.21 8E-5	100 0.04
W4	Drop, Puncture, Lid Failure in Underground	25 0.01	0.37 2E-4	0.37 1E-4	180 0.07
W5	Container Fire	113 0.06	1.7 9E-4	1.7 7E-4	N/A
W6	Hoist Failure	CH-TRU 8,575 4 RH-TRU 2,700 1	CH-TRU 130 0.07 RH-TRU 40 0.02	CH-TRU 130 0.05 RH-TRU 40 0.02	See Text
W7	Roof Fall	350 0.2	4.7 2E-3	4.7 2E-3	See Text
W8	RH-TRU Waste Canister Breach	9 4E-3	0.13 7E-5	0.13 5E-5	0.0 0

Table G-44
Hazardous Chemical Carcinogenic Impacts of WIPP Disposal Accidents Under the Proposed Action and Action Alternative 1

SEIS-II Accident Scenario	Accident Description	Hazardous Constituents	Population (cancers)	MEI (probability of cancer)	Maximally Exposed Noninvolved Worker (probability of cancer)	Maximally Exposed Involved Worker (probability of cancer)
W1	Drop, Lid Failure in Waste Handling Building	VOCs Metals	2E-6 4E-11	2E-10 6E-13	2E-10 6E-13	1E-7 3E-10
W2	Drop, Puncture Lid Failure in Waste Handling Building	VOCs Metals	5E-6 8E-11	5E-10 1E-12	5E-10 1E-12	4E-7 5E-10
W3	Drop, Lid Failure in Underground	VOCs Metals	2E-6 3E-11	2E-10 5E-13	2E-10 5E-13	1E-7 2E-10
W4	Drop, Puncture, Lid Failure in Underground	VOCs Metals	5E-6 6E-11	5E-10 8E-13	5E-10 8E-13	4E-7 4E-10
W5	Container Fire	VOCs Metals	0.0 2E-10	0.0 2E-12	0.0 2E-12	N/A
W6	Hoist Failure (CH-TRU Waste)	VOCs Metals	5E-5 2E-8	5E-9 3E-10	5E-9 3E-10	See Text
W6	Hoist Failure (RH-TRU Waste)	VOCs Metals	5E-6 3E-9	5E-10 5E-11	5E-10 5E-11	See Text
W7	Roof Fall	VOCs Metals	1E-4 6E-10	1E-8 9E-12	1E-8 9E-12	See Text
W8	RH-TRU Waste Canister Breach	VOCs Metals	5E-6 5E-12	5E-10 7E-14	5E-10 7E-14	4E-7 0

N/A = Not Applicable

Table G-45
Hazardous Chemical Noncarcinogenic Impacts of WIPP Disposal Accidents Under the Proposed Action and Action Alternative 1

SEIS-II Accident Scenario	Accident Description	Hazardous Constituents	MEI (fraction of IDLH-equivalent)	Maximally Exposed Noninvolved Worker (fraction of IDLH-equivalent)	Maximally Exposed Involved Worker (fraction of IDLH-equivalent)
W1	Drop, Lid Failure in Waste Handling Building	VOCs Metals	2E-6 2E-8	2E-6 2E-8	1E-3 1E-5
W2	Drop, Puncture Lid Failure in Waste Handling Building	VOCs Metals	7E-6 4E-8	7E-6 4E-8	4E-3 2E-5
W3	Drop, Lid Failure in Underground	VOCs Metals	2E-6 2E-8	2E-6 2E-8	1E-3 1E-5
W4	Drop, Puncture, Lid Failure in Underground	VOCs Metals	7E-6 3E-8	7E-6 3E-8	4E-3 2E-5
W5	Container Fire	VOCs Metals	0.0 9E-8	0.0 9E-8	N/A
W6	Hoist Failure (CH-TRU Waste)	VOCs Metals	6E-5 1E-5	6E-5 1E-5	See Text
W6	Hoist Failure (RH-TRU Waste)	VOCs Metals	7E-6 2E-6	7E-6 2E-6	See Text
W7	Roof Fall	VOCs Metals	2E-5 3E-7	2E-5 3E-7	See Text
W8	RH-TRU Waste Canister Breach	VOCs Metals	7E-6 3E-9	7E-6 3E-9	0 0

N/A = Not Applicable

Two accident scenarios, the hoist failure (Accident Scenario W6) and the roof fall (Accident Scenario W7), could have impacts ranging from negligible to lethal effects for any involved workers in the immediate area were the accident to occur. There are typically four underground workers involved in emplacement operations. Some or all of these workers could be killed if they were in the immediate area when the accidents occurred.

The highest air concentration to which the MEI, maximally exposed noninvolved worker, and maximally exposed involved worker could be exposed were compared to the ERPG values (see Table G-3). The ratio of the exposure air concentration and the ERPG value are presented in Table G-46.

For the MEI and maximally exposed noninvolved worker, the roof fall scenario (W7) could cause a reversible noncarcinogenic impact, as indicated by the ERPG-1 ratios of two hazardous chemicals: 2 for carbon tetrachloride and 1 for beryllium. Accidents W5, W6, and W7 may cause irreversible but non-life-threatening health effects if some hazardous chemicals are present in the waste container at the level assumed in the analysis. Under Accident Scenario W5, the impacts could result from releases of lead and mercury, both of which have an ERPG-2 ratio of 2. Under Accident Scenario W6, the impacts could result from releases of 1,1,2,2-tetrachloroethane (ERPG-2 ratio of 2) or lead and mercury (ERPG-2 ratios are 43 and 46, respectively). Under Accident Scenario W7, the impacts could result from releases of lead and mercury, both of which have an ERPG-2 ratio of 1. The hoist failure accident (Accident Scenario W6) could have the most serious noncarcinogenic accident impact potential, with ERPG-3 ratios of 1 for methylene chloride and 3 for beryllium. These ratios indicate that life-threatening effects would be expected.

Table G-46
Ratios of Exposure Air Concentrations to ERPG-2 Values for WIPP Disposal Accidents Under the Proposed Action and Action Alternative 1 [a]

SEIS-II Accident Scenario	Accident Description	Hazardous Constituents	MEI and Maximally Exposed Noninvolved Worker Air Concentration to ERPG-2 Ratio	Maximally Exposed Involved Worker Air Concentration to ERPG-2 Ratio
W1	Container Drop and Lid Seal Failure	VOC Metals	0.09 0.1	2 0.01
W2	Container Puncture, Crop and Lid Seal Failure	VOC Metals	0.3 0.2	7 3
W3	Container and Lid Seal Failure	VOC Metals	0.09 0.08	2 0.01
W4	Container Puncture, Drop, and Lid Seal Failure	VOC Metals	0.3 0.2	7 3
W5	Container Fire	Metals	2	N/A N/A
W6	Failure of the Waste Shaft Hoist (CH-TRU Waste)	VOC Metals	2 46	See Text
W6	Failure of the Waste Shaft Hoist (RH-TRU Waste)	VOC Metals	0.3 7	See Text
W7	Roof Fall	VOC Metals	13 1	See Text
W8	RH-TRU Waste Canister Breach	VOC Metals	0.3 0.01	0 0

[a] These exposure air concentration to ERPG-2 ratios are the highest of any individual hazardous chemical.

N/A = Not Applicable

The maximally exposed involved worker would experience the same impacts from accidents W1 and W3 and from accidents W2 and W4. The differences between W1 and W3 and between W2 and W4 are their locations of occurrence. The exposure of the involved worker is assumed to be the same whether the accident occurs in the Waste Handling Building or underground. Based on ERPG ratio estimates for Accident Scenarios W1 and W3, methylene chloride exposures may be life-threatening (ERPG-3 ratio of 1); 1,1,2,2-tetrachlorethane might cause irreversible, nonlife-threatening impacts (ERPG-2 ratio of 2); and carbon tetrachloride exposures may result in minor, reversible health impacts (ERPG-1 ratio of 1.0). Based on ERPG ratio estimates for Accident Scenarios W2 and W4, methylene chloride exposures may be life-threatening (ERPG-3 ratio of 3); 1,1,2,2-tetrachloroethane, lead, and mercury exposures might cause irreversible, but nonlife-threatening impacts (ERPG-2 ratios of 7, 3, and 3, respectively); and carbon tetrachloride, chlorobenzene, and methyl ethyl ketone might create reversible health impacts (ERPG-1 ratios of 3, 1, and 1, respectively).

G.4.3.2 Accident Impacts for the Action Alternative 2 Subalternatives

The thermally treated waste form in the Action Alternative 2 subalternatives would reduce the impacts of WIPP disposal accidents. Potential radiological impacts would predominate for all

accidents. There would be no expected cancer incidence in the exposed population and very low probabilities of cancer to exposed individuals from hazardous metals for all accidents (there would be no VOCs in thermally treated waste). As for the Proposed Action and Action Alternative 1, only the hoist failure (Accident Scenario W6) would result in radiation-related LCFs in the exposed population around WIPP. The radiological impact is greater for the Action Alternative 2 subalternatives than for the Proposed Action and Action Alternative 1 because the thermally treated waste is more likely to completely brittle-fracture upon impact and create a larger quantity of respirable particles than is the waste treated to planning-basis WAC. Up to 26 LCFs could occur in an exposed sector-population from a hoist failure involving CH-TRU waste, and seven LCFs could occur from a hoist failure involving RH-TRU waste. The probability of an LCF to the MEI would be 0.4 (40 percent chance) for the CH-TRU waste accident scenario and 0.1 (10 percent chance) for the RH-TRU waste accident scenario. Table G-47 presents the radiological impacts from WIPP disposal accidents under Action Alternative 2.

Table G-47
Radiological Impacts of WIPP Disposal Accidents
Under the Action Alternative 2 Subalternatives

SEIS-II Accident Scenario	Accident Description	Population (person-rem, LCFs)		MEI (rem, probability of LCF)		Maximally Exposed Noninvolved Worker (rem, probability of LCF)		Maximally Exposed Involved Worker (rem, probability of LCF)
W1	Drop, Lid Failure in WHB	1.7 9E-4		0.026 1E-5		0.026 1E-5		10 4E-3
W2	Drop, Puncture Lid Failure in WHB	1.7 9E-4		0.026 1E-5		0.026 1E-5		10 4E-3
W3	Drop, Lid Failure in Underground	1.4 7E-4		0.021 1E-5		0.021 8E-6		10 4E-3
W4	Drop, Puncture, Lid Failure in Underground	1.4 7E-4		0.021 1E-5		0.021 8E-6		10 4E-3
W5	Container Fire	N/A		N/A		N/A		N/A
W6	Hoist Failure	CH-TRU 47,000 24	RH-TRU 15,000 7	CH-TRU 700 0.4[d]	RH-TRU 220 0.1	CH-TRU 700 0.3[d]	RH-TRU 220 0.1	See Text
W7	Roof Fall	31 0.02		0.47 2E-4		0.47 2E-4		See Text
W8	RH-TRU Waste Canister Breach	0		0		0		0

N/A = Not Applicable

Maximum annual dose is 35 rem and remains above 20 rem per year for the first six years; therefore, annual carcinogenic risk for the first six years is calculated without using the low dose-rate dose-reduction factor of two.

Potential carcinogenic impacts from exposure to VOCs and hazardous metals released during WIPP disposal accidents are presented in Table G-48. As noted above, no cancers would be expected in the exposed population, and impacts to individuals would be very low.

Potential noncarcinogenic impacts from exposure to hazardous metals released during an accident are presented in Table G-49. No noncarcinogenic health effects would be expected. The majority of the small noncarcinogenic impact is from release of mercury in the waste.

Table G-48
Hazardous Metal Carcinogenic Impacts of WIPP Disposal Accidents Under the Action Alternative 2 Subalternatives

SEIS-II Accident Scenario	Accident Description	Population (cancers)	MEI (probability of cancer)	Maximally Exposed Noninvolved Worker (probability of cancer)	Maximally Exposed Involved Worker (probability of cancer)
W1	Drop, Lid Failure in WHB	1E-11	2E-13	2E-13	1E-8
W2	Drop, Puncture Lid Failure in WHB	1E-11	2E-13	2E-13	1E-8
W3	Drop, Lid Failure in Underground	8E-12	2E-13	2E-13	1E-8
W4	Drop, Puncture, Lid Failure in Underground	8E-12	2E-13	2E-13	1E-8
W5	Container Fire	N/A	N/A	N/A	N/A
W6	Hoist Failure (CH-TRU Waste)	3E-7	4E-9	4E-9	See Text
W6	Hoist Failure (RH-TRU Waste)	2E-8	3E-10	3E-10	See Text
W7	Roof Fall	2E-10	2E-12	2E-12	See Text
W8	RH-TRU Waste Canister Breach	0	0	0	0

N/A = Not Applicable

Table G-49
Hazardous Metal Noncarcinogenic Impacts of WIPP Disposal Accidents Under the Action Alternative 2 Subalternatives

SEIS-II Accident Scenario	Accident Description	MEI (fraction of IDLH-equivalent)	Maximally Exposed Noninvolved Worker (fraction of IDLH-equivalent)	Maximally Exposed Involved Worker (fraction of IDLH-equivalent)
W1	Drop, Lid Failure in WHB	6E-9	6E-9	5E-4
W2	Drop, Puncture Lid Failure in WHB	6E-9	6E-9	5E-4
W3	Drop, Lid Failure in Underground	5E-9	5E-9	5E-4
W4	Drop, Puncture, Lid Failure in Underground	5E-9	5E-9	5E-4
W5	Container Fire	N/A	N/A	N/A
W6	Hoist Failure (CH-TRU Waste)	2E-4	2E-4	See Text
W6	Hoist Failure (RH-TRU Waste)	1E-5	1E-5	See Text
W7	Roof Fall	8E-8	8E-8	See Text
W8	RH-TRU Waste Canister Breach	0	0	0

N/A = Not Applicable

As for the Proposed Action and Action Alternative 1, the hoist failure (Accident Scenario W6) and the roof fall (Accident Scenario W7) could have a range of impacts from negligible to lethal effects for any involved workers in the immediate area of the accident. There are typically four underground workers involved in emplacement operations. Some or all of these workers could be killed if they were in the immediate area when the accidents occurred.

The highest air concentration to which the MEI, maximally exposed noninvolved worker, and maximally exposed involved worker could be exposed were compared to the ERPG values (see Table G-3). The ratio of the exposure air concentration and the ERPG value are presented in Table G-50. The only accident estimated to result in noncarcinogenic impacts to the MEI and maximally exposed noninvolved worker, based on the ERPG ratio analysis, would be the hoist failure accident (Accident Scenario W6). The releases of beryllium, lead, and mercury (ERPG-2 ratios of 38, 2, and 2, respectively) could result in life-threatening intakes. No releases from W1, W2, W3, or W4 were estimated to have any noncarcinogenic impact to involved workers, based on the ERPG ratio analyses.

Table G-50
Ratios of Exposure Air Concentrations to ERPG-2 Values
Under the Action Alternative 2 Subalternatives [a]

SEIS-II Accident Scenario	Hazardous Constituents	MEI and Maximally Exposed Noninvolved Worker: Air Concentration to ERPG-2 Ratio	Maximally Exposed Involved Worker: Air Concentration to ERPG-2 Ratio
W1	Metals	0.5	0.5
W2	Metals	0.02	0.5
W3	Metals	0.5	0.5
W4	Metals	0.02	0.5
W5	Metals	N/A	N/A
W6 (CH-TRU Waste)	Metals	650	See Text
W6 (RH-TRU Waste)	Metals	49	See Text
W7	Metals	0.3	See Text
W8	Metals	0.02	0

[a] These exposure air concentration to ERPG-2 ratios are the highest of any individual hazardous chemical.

N/A = Not Applicable

G.4.3.3 Accident Impacts for Action Alternative 3

Compared to accidents involving waste packaged to meet the planning-basis WAC, the consolidated waste form in Action Alternative 3 waste would reduce the impacts of most WIPP disposal. Potential radiological impacts would predominate for all accidents. There would be no expected cancer incidence in the exposed population and very low probabilities of cancer to exposed individuals from VOCs and hazardous metals for all accidents. As for the Proposed Action, Action Alternative 1, and Action Alternative 2, only, the hoist failure (Accident Scenario W6) would result in radiation-related LCFs in the exposed population around WIPP. The radiological impact is identical to that of Action Alternative 2 and greater than for the Proposed Action and Action Alternative 1, because the grouted waste form also is assumed to brittle-fracture upon impact and create a larger quantity of respirable particles than is the waste treated to planning-basis WAC. Up

to 26 LCFs could occur in an exposed sector-population from a hoist failure involving CH-TRU waste, and 7 LCFs could occur from a hoist failure involving RH-TRU waste. The probability of an LCF to the MEI would be 0.4 (40 percent chance) for the CH-TRU waste accident scenario and 0.1 (10 percent chance) for the RH-TRU waste accident scenario. Table G-51 presents the radiological impacts from WIPP disposal accidents under Action Alternative 3.

Table G-51
Radiological Impacts of WIPP Disposal Accidents Under Action Alternative 3

SEIS-II Accident Scenario	Accident Description	Population (person-rem, LCFs)		MEI (rem, probability of LCF)		Maximally Exposed Noninvolved Worker (rem, probability of LCF)		Maximally Exposed Involved Worker (rem, probability of LCF)
W1	Drop, Lid Failure in WHB	1.7 9E-4		0.026 1E-5		0.026 1E-5		10 4E-3
W2	Drop, Puncture Lid Failure in WHB	1.7 9E-4		0.026 1E-5		0.026 1E-5		10 4E-3
W3	Drop, Lid Failure in Underground	1.4 7E-4		0.021 1E-5		0.021 8E-6		10 4E-3
W4	Drop, Puncture, Lid Failure in Underground	1.4 7E-4		0.021 1E-5		0.021 8E-6		10 4E-3
W5	Container Fire	1.8 9E-4		0.025 1E-5		0.025 1E-5		N/A
W6	Hoist Failure	CH-TRU 47,000 24	RH-TRU 15,000 7	CH-TRU 700 0.4[a]	RH-TRU 220 0.1	CH-TRU 700 0.3[a]	RH-TRU 220 0.1	See Text
W7	Roof Fall	31 0.02		0.47 2E-4		0.47 2E-4		See Text
W8	RH-TRU Waste Canister Breach	0		0		0		0

[a] Maximum annual dose is 35 rem and remains above 20 rem per year for the first 6 years. Therefore, annual carcinogenic risk for the first 6 years was calculated without using the low dose rate dose reduction factor of 2.

N/A = Not Applicable

Potential carcinogenic impacts from exposure to VOCs and hazardous metals released during WIPP disposal accidents are presented in Table G-52. As noted above, no cancer incidence would be expected in the exposed population, and impacts to individuals would be very low.

Potential noncarcinogenic impacts from exposure to VOCs and hazardous metals released during an accident are presented in Table G-53. No noncarcinogenic health effects would be expected. The majority of the small noncarcinogenic impact would be from 1,1,2,2-tetrachloroethane released.

As for the Proposed Action, Action Alternative 1 and Action Alternative 2, both the hoist failure (Accident Scenario W6) and the roof fall (Accident Scenario W7) could have a range of impacts, from negligible to lethal effects for any involved workers in the immediate area were the accident to occur. There are typically four underground workers involved in emplacement operations. Some or all of these workers could be killed if they were in the immediate area when the accidents occurred.

Table G-52
Hazardous Chemical Carcinogenic Impacts of WIPP Disposal Accidents Under Action Alternative 3

SEIS-II Accident Scenario	Accident Description	Hazardous Constituents	Population (cancers)	MEI (probability of cancer)	Maximally Exposed Noninvolved Worker (probability of cancer)	Maximally Exposed Involved Worker (probability of cancer)
W1	Drop, Lid Failure in WHB	VOCs Metals	1E-6 4E-12	1E-10 5E-14	1E-10 5E-14	7E-8 2E-11
W2	Drop, Puncture Lid Failure in WHB	VOCs Metals	3E-6 4E-12	3E-10 5E-14	3E-10 5E-14	2E-7 2E-11
W3	Drop, Lid Failure in Underground	VOCs Metals	1E-6 3E-12	1E-10 4E-14	1E-10 4E-14	7E-8 2E-11
W4	Drop, Puncture, Lid Failure in Underground	VOCs Metals	3E-6 3E-12	3E-10 4E-14	3E-10 4E-14	2E-7 2E-11
W5	Container Fire	VOCs Metals	0.0 4E-12	0.0 5E-14	0.0 5E-14	N/A
W6	Hoist Failure (CH-TRU Waste)	VOCs Metals	3E-5 1E-7	3E-9 1E-9	3E-9 1E-9	See Text
W6	Hoist Failure (RH-TRU Waste)	VOCs Metals	3E-6 7E-9	3E-10 1E-10	3E-10 1E-10	See Text
W7	Roof Fall	VOCs Metals	7E-5 5E-11	7E-9 7E-13	7E-9 7E-13	See Text
W8	RH-TRU Waste Canister Breach	VOCs Metals	3E-6 0	3E-10 0	3E-10 0	0 0

N/A = Not Applicable

Table G-53
Hazardous Chemical Noncarcinogenic Impacts of WIPP Disposal Accidents Under Action Alternative 3

Accident Scenarios	Accident Description	Hazardous Constituents	MEI (fraction of IDLH-equivalent)	Maximally Exposed Noninvolved Worker (fraction of IDLH-equivalent)	Maximally Exposed Involved Worker (fraction of IDLH-equivalent)
W1	Drop, Lid Failure in WHB	VOCs Metals	6E-7 2E-9	6E-7 2E-9	4E-4 9E-7
W2	Drop, Puncture Lid Failure in WHB	VOCs Metals	2E-6 2E-9	2E-6 2E-9	1E-3 9E-7
W3	Drop, Lid Failure in Underground	VOCs Metals	6E-7 1E-9	6E-7 1E-9	4E-4 7E-7
W4	Drop, Puncture, Lid Failure in Underground	VOCs Metals	2E-6 1E-9	2E-6 1E-9	1E-3 7E-7
W5	Container Fire	VOCs Metals	0.0 2E-9	0.0 2E-9	N/A
W6	Hoist Failure (CH-TRU Waste)	VOCs Metals	2E- 5E-5	2E-5 5E-5	See Text
W6	Hoist Failure (RH-TRU Waste)	VOCs Metals	2E-6 4E-6	2E-6 4E-6	See Text
W7	Roof Fall	VOCs Metals	5E-5 3E-8	5E-5 3E-8	See Text
W8	RH-TRU Waste Canister Breach	VOCs Metals	2E-6 0	2E-6 0	0 0

N/A = Not Applicable

The highest air concentration to which the MEI, maximally exposed noninvolved worker, and maximally exposed involved worker could be exposed were compared to the ERPG values (see Table G-3). The ratio of the exposure air concentration and the ERPG value are presented in Table G-54. Based on the ERPG analyses, the most serious noncarcinogenic impacts would result from Accident Scenario W6. Life-threatening releases may result from beryllium and methylene chloride releases (ERPG-3 ratios of 12 and 1, respectively). Irreversible, but non-life-threatening health impacts could result from intakes of lead and mercury (ERPG-2 ratios of 200 for both). Reversible impacts or objectionable odors could result from potential carbon tetrachloride releases (ERPG-1 ratio of 1). Accident Scenario W7 could also create potential noncarcinogenic impacts to the MEI and noninvolved worker. Potential 1,1,2,2-tetrachloroethane releases could result in irreversible noncarcinogenic impacts (ERPG-2 ratio of 5) and potential carbon tetrachloride releases could result in reversible impacts (ERPG-1 ratio of 3).

Table G-54
Ratios of Exposure Air Concentrations to ERPG-2 Values for WIPP Disposal Accidents Under Action Alternative 3[a]

SEIS-II Accident Scenario	Hazardous Constituents	MEI and Maximally Exposed Noninvolved Worker	Maximally Exposed Involved Worker
		Air Concentration to ERPG-2 Ratio	Air Concentration to ERPG-2 Ratio
W1	VOC	0.09	2
	Metals	0.008	0.2
W2	VOC	0.3	7
	Metals	0.008	0.2
W3	VOC	0.09	2
	Metals	0.006	0.2
W4	VOC	0.3	7
	Metals	0.006	0.2
W5	Metals	0.04	N/A
W6 (CH-TRU Waste)	VOC	2	See Text
	Metals	200	
W6 (RH-TRU Waste)	VOC	0.3	See Text
	Metals	16	
W7	VOC	5	See Text
	Metals	0.1	
W8	VOC	0.3	0
	Metals	0	0

[a] These exposure air concentration to ERPG-2 ratios are the highest of any individual hazardous chemical.

N/A = Not Applicable

Based on ERPG analysis of Accident Scenarios W1 and W3, the maximally exposed involved worker could have a life-threatening exposure to methylene chloride releases (ERPG-3 ratio of 1) or experience irreversible, minor impacts from carbon tetrachloride releases (ERPF-1 ratio of 1).

Based on ERPG analysis of Accident Scenarios W2 and W4, the maximally exposed involved worker could have impacts identical to those of Accident Scenarios W1 and W3, but the ERPG ratios are increased by a factor of three.

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APPENDIX H

APPENDIX H
LONG-TERM CONSEQUENCE ANALYSIS FOR PROPOSED ACTION AND ACTION ALTERNATIVES

H.1 INTRODUCTION

This appendix describes the analytical methods, codes, and exposure calculations used to determine the long-term radiological and hazardous chemical impacts from the WIPP disposal system under the Proposed Action and the action alternatives discussed in Chapter 5. An overview of the changes in the performance assessment (PA) analysis is presented, as are summaries of conceptual models used for the disposal system and waste source-term release, and codes used for radiation dose and chemical exposure. Detailed background information on the Waste Isolation Pilot Plant (WIPP) disposal system, descriptions of the conceptual models of releases, and selected data input parameters may be found in supporting regulatory compliance documents currently under development by the U.S. Department of Energy (DOE or the Department).

H.2 OVERVIEW OF CHANGES IN PERFORMANCE ASSESSMENT ANALYSIS SINCE THE 1990 *FINAL SUPPLEMENT ENVIRONMENTAL IMPACT STATEMENT FOR THE WASTE ISOLATION PILOT PLANT* (SEIS-I)

The long-term radiological and hazardous chemical impacts from the WIPP disposal system were analyzed in SEIS-I. However, a new analysis was deemed necessary for this *1996 Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II) because of (1) revised alternatives and their associated waste volumes and inventories, (2) new data, and (3) substantial changes in WIPP PA approaches and computational tools. A discussion of these new developments is summarized below. The changes in alternatives and associated waste volumes and inventories are discussed in detail in Chapter 3 and Appendix A.

H.2.1 Recent Testing Programs

The WIPP program has been conducting ongoing testing programs to provide technical justification for major components of the conceptual model for the WIPP disposal system. These programs have been developed to meet the needs of the PA and its level of modeling sophistication. Data has been collected in an effort to understand the key processes and critical parameters of disposal system design and performance. These key processes and critical parameters include the following:

- Actinide solubility and colloid adsorption studies and their effect on controlling source-term release and near-field transport in the Salado Formation
- Salt creep and its impact on waste panel closure and healing of the disturbed rock zone (DRZ)
- Physical and geochemical characteristics of brine inflow into the repository and their influence on source-term release and near-field transport in the Salado Formation

- Gas generation and its effect on brine inflow and dilation and fracturing of the DRZ
- Dilation and fracturing of rocks within the DRZ, particularly in the anhydrite beds above and below the repository, and their effect on brine flow and transport in the vicinity of the repository
- Hydrologic and transport properties of the Salado Formation and their impacts on near-field and far-field contaminant transport
- Hydrologic and transport properties of the units above the Salado Formation, most notably the Culebra Member of the Rustler Formation, and their effect on far-field contaminant transport.

Results of these testing and experimental programs have been used to select and revise parameters and parameter distributions used in numerical models employed in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) and in the more recent efforts of the *Draft Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant* (DCCA) (DOE 1995a) and *Draft No-Migration Variance Petition* (DOE 1995b).

Some of the key ongoing laboratory and field testing programs that have resulted in updated parameters and parameter distributions used in WIPP PA analyses since the SEIS-I (DOE 1990) are summarized in Table H-1.

H.2.2 Computational Tools and Codes

The computer codes and databases used to assess the long-term performance of the WIPP disposal system have evolved substantially since the SEIS-I analysis was completed. A major development effort accompanied the preliminary PA of WIPP in 1992. The primary areas of enhancement include simulation of coupled gas generation, brine migration, and salt creep (SNL 1992). Conceptual models and databases supporting PA calculations were modified and enhanced for the Systems Prioritization Methodology (SPM) process conducted in 1994 and 1995. Further code development and enhancement have continued to support more recent regulatory compliance effort: associated with the development of the *Draft No-Migration Variance Petition* (DOE 1995b) and the DCCA (DOE 1995a). The following is a description of key developments since SEIS-I.

In the SEIS-I analysis, long-term radiological and hazardous chemical impacts of the WIPP disposal system were determined by accepted conceptual models and computer codes implemented by DOE in PA programs. The two principal codes in use at that time were the NEFTRAN and SWIFT II codes.

NEFTRAN, a groundwater flow and radionuclide transport code developed by Sandia National Laboratories (SNL) for the U.S. Nuclear Regulatory Commission, was used to calculate radionuclide releases from an undisturbed repository (Longsine et al. 1987). NEFTRAN was designed with the assumption that all substantial groundwater flow and radionuclide transport progresses along discrete one-dimensional legs or paths. A flow field is represented by a network of these legs. The solution of the flow equations in NEFTRAN requires pressure boundary conditions specified in the input data.

Table H-1
Summary of Key Investigations or Experiments Relevant to WIPP Performance Assessment Analysis

Investigation or Experiment	Description	Influenced Parameters	Current Status	Key Reference(s)
Source-term Release				
Actinide Solubility Studies	Experimental work necessary to develop the models for mobile dissolved actinide concentrations is being performed under five separate contracts. As of March 21, 1995, these contracts are with Pacific Northwest National Laboratory, Lawrence Livermore National Laboratory, Lawrence Berkeley Laboratory, Florida State University, and Los Alamos National Laboratory.	Solubility limits for actinides	Ongoing	Results are summarized in Novak et al. (1995).
Salado Formation				
Large-Scale Brine Inflow Experiments	Large-scale brine inflow experiments in Room Q at WIPP was conducted to provide scaling information for brine inflow measurements from small-scale boreholes to repository-size excavations, pore pressure, and permeability. From July 1989 to May 1994, data were collected using the following methods: vacuuming brine from natural sumps formed by depressions in the floor into preweighed flasks; manually absorbing brine with sponges; and vacuuming brine from a prepared sump near the inner bulkhead using a remote collection device into preweighed flasks.	Brine inflow and waste degradation rates	Ongoing	Results of these data collection activities are summarized in the Salado position paper (Howarth et al. 1995).
Small-Scale Brine Inflow Experiments	Small-scale brine inflow experiments were conducted at the WIPP facility horizon from September 1987 to June 1993, to provide data for use in the development and validation of a mechanistic model for brine inflow into the repository. A total of 17 boreholes, divided among Room D (10 boreholes), Room L4 (2 boreholes), and Room Q access drift (5 boreholes), were monitored for brine accumulation.	Brine inflow and waste degradation rates	Ongoing	Results of these measurements are documented in Finley et al. (1992) and McTigue (1993) and in the Salado position paper (Howarth et al. 1995).
Brine Sampling and Evaluation Program	Observational data on brine flow to underground working and exploratory boreholes have been collected routinely since 1985 under the Brine Sampling and Evaluation Program. This program goes beyond the Room Q experiments and other brine collection programs, in that data have been collected from excavation and exploratory boreholes over the entire WIPP underground facility.	Brine inflow and waste degradation rates	Ongoing	Results of these measurements are summarized in the Salado position paper (Howarth et al. 1995).

Table H-1
Summary of Key Investigations or Experiments
Relevant to WIPP Performance Assessment Analysis—Continued

Investigation or Experiment	Description	Influenced Parameters	Current Status	Key Reference(s)
Salado Formation - Continued				
Geophysical Surveys and Fluid Flow	Estimates of the variation in permeability were made from electrical data acquired along the length of a borehole as part of the Salado Two-Phase Flow Program. The borehole was drilled to assess anhydrite core damage and properties restoration (Howarth et al. 1995). Calculated permeabilities match closely with laboratory and field experimental data. Resistivity data collected in Room Q were collected from 1989 to 1993. Self-potentials have also been routinely measured in Room Q as a background check for electrical surveys.	Salado permeabilities	Ongoing	Results are summarized in the Salado position paper (Howarth 1994).
Hydrofracture Experiments	Three separate experiments were conducted in the Salado Formation to investigate conditions of fracture formation and fracture properties. One experiment described hydrofractures for the facility horizon salt. The second experiment observed pressure-dependent permeability in MB 138 as part of the Salado Far-field Testing Program. A third experiment coupled permeability and hydrofracture tests performed in Marker Beds 138 and 140.	Salado permeabilities and fracture characteristics	Ongoing	Results of these tests are summarized in the Salado position paper (Howarth et al. 1995).
Non-Salado Formation Investigations				
Laboratory and field studies of Culebra fracture and matrix properties	Tracer tests were conducted at the H-3, H-6, and H-11 hydropads to estimate the fracture porosity in the Culebra Dolomite of the Rustler Formation. Examinations of sorbing tracer tests are currently being done at the H-19 hydropad.	Hydraulic and transport properties of the Culebra	Ongoing	A summary is provided in the non-Salado position paper (Axness et al. 1995).
Actinide retardation in the Culebra	Scoping calculations are being done to evaluate actinide retardation in the Culebra Dolomite matrix and clay mineral-lined fracture surfaces.	Chemical retardation in the Culebra	Ongoing	A summary is provided in the non-Salado position paper (Axness et al. 1995).
Enhanced colloid experimental program/ concentration and transport of colloid carriers	This program includes an investigation of actinide concentrations contained by mobile colloids and an evaluation of colloid-facilitated radionuclide transport in the Culebra Dolomite. The evaluation takes into consideration the two major types of colloidal particles that may be important at WIPP. Actinide intrinsic colloids are being investigated at LLNL. Carrier colloids, which form by sorption of actinides onto otherwise nonradioactive colloidal particles, are being investigated at SNL. Both programs use initial stability screening experiments to eliminate kinetically or chemically unstable colloids from further consideration.	Colloid characteristics and chemical processes affecting transport in the Culebra	Ongoing	A summary is provided in the non-Salado position paper (Axness et al. 1995).

SWIFT II is a fully transient, three-dimensional code that solves equations for groundwater flow and radionuclide transport in both porous and fractured media. In SEIS-I (DOE 1990), SWIFT II was used to calculate releases from a disturbed repository. Also, SWIFT II was used to establish the groundwater flow field in the Culebra Dolomite and to simulate the injection of pressurized brine from the Castile Formation into the Culebra Dolomite.

The *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) used a suite of new codes and modules that substantially improved simulation capabilities from those in SEIS-I. Improvements were made in the areas of simulating two-phase flow and salt creep in the vicinity of the repository within the Salado Formation and in the representation of transmissivity fields, flow fields, and transport calculations within the Culebra Dolomite of the Rustler Formation. Table H-2 briefly describes the key modules that were used for the first time in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* calculations and are relevant to this analysis.

The SPM, initiated by DOE in March 1994, was the result of an effort to define the most viable combinations of scientific investigation, engineering alternatives, and the planning-basis Waste Acceptance Criteria (WAC) (DOE 1996e) for supporting WIPP compliance applications. As a part of this SPM development process, DOE established a technical baseline by which to summarize the conceptual models of disposal system performance and to assemble new information from technical position papers for use in the SPM process. To the extent possible, the SPM process implemented

Table H-2
Summary of Computer Codes Used in the 1992 WIPP Performance Assessment

Computer Code	Description
BRAGFLO	Module used to describe the two-phase flow of gas and brine through a porous, heterogeneous reservoir. This module is used to simulate two-phase (gas and brine) flow through the repository, shaft seals, and surrounding environment.
PANEL	Module used to calculate radionuclide concentrations in the brine phase with an equilibrium-mixing cell approach. This module calculates the rate of discharge and cumulative discharge of radionuclides from a repository panel through an intrusion borehole. Discharge is a function of the fluid flow rate, nuclide solubility, and remaining inventory.
SANCHO	Module used to simulate quasi-static, large-deformation, inelastic response of halite. These simulations are used in the calculation of waste porosity as a function of time and moles of gas generated.
CUTTINGS_S	Module used to calculate the quantity of radioactive material brought to the surface as cuttings and cavings as a result of an exploratory drilling operation that penetrates a waste panel.
SECOFL-2D **SECOTP-2D**	Modules are groundwater flow and transport models used to calculate subsurface transport through the Culebra Dolomite of the Rustler Formation to the land-withdrawal boundary. Flow calculations assumed a single matrix, porous medium (dolomite). Transport calculations modeled single- or dual-porosity transport through an idealized fractured medium. Retardation in the dolomite matrix and in the fracture-lining clay could be included simultaneously or separately.
GRASP-INV	Module used to generate multiple, plausible transmissivity fields for use by SECO-2DH. This module was an improvement, in that it produced calibrated transmissivity fields that reproduced measured values at well locations.
GENII-S	Module used to estimate potential radiation doses to humans from radionuclides in the environment.

the computer codes used in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) with modifications for conceptual model enhancements and new information identified in the development of the technical baseline. Details of the modifications and new information are described in *The Second Iteration of the Systems Prioritization Method: A Systems Prioritization and Decision-Aiding Tool for the Waste Isolation Pilot Plant: Final Report Revision 1* (SPM-2) (SNL 1995).

With a few exceptions, the same codes were used in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), and in the current regulatory PA applications and related documentation. Key new developments included the following: (1) the SANTOS (formally the SANCHO) module that was used to simulate quasi-static, large-deformation, inelastic response of halite has now been incorporated and integrated in the computational framework of the BRAGFLO module (described in Section H.3.3), and (2) the NUTS module is currently being used to simulate the transport and decay of multiple radioactive components in three dimensions through the fracture and matrix continuum. This module can be implemented to simulate transport in single-porosity, dual-porosity, and dual-permeability media. This capability is now used in place of the PANEL module to model transport contaminants in brine within the repository to the surrounding rock. NUTS is described in more detail in Section H.3.3.

H.3 DESCRIPTION OF APPROACH

The purpose of this analysis is to examine the long-term consequences from radionuclides and hazardous constituents disposed of at WIPP under the Proposed Action and Action Alternatives 1, 2, and 3. All of these alternatives address the long-term radiological and hazardous chemical impacts of transuranic (TRU) waste disposal after the loss of institutional control, which would occur 100 years after the closure of WIPP.

The analysis presented in SEIS-I addressed both the undisturbed performance of WIPP and the effects of human intrusion (exploratory drilling) (DOE 1990). Analyses were conducted with selected computer runs that incorporated both realistic estimates of parameter values (median) and values chosen to examine degraded or pessimistic performance (75th percentile) of WIPP. As discussed in the following sections, the results of this analysis indicate that there is remarkably little difference between the amounts of radionuclide and hazardous chemical releases from the repository when the analysis is conducted using median and 75th percentile values. However, the analysis for both median and 75th percentile values were conducted for the Proposed Action and each action alternative in order to demonstrate that the results are conservative.

The approach for this SEIS-II is based on four major elements used in SEIS-I; however, SEIS-II also incorporated computer codes and data developed since SEIS-I. The SEIS-II approach is based on the following:

- Deterministic analyses derived from databases supporting current regulatory PA activities using a selected number of computer runs
- Analyses of performance conducted using both median and 75th percentile values for model parameters selected
- Analyses of both undisturbed and disturbed (human intrusion exploratory drilling) conditions

- Numerical evaluation of long-term disposal system performance using codes developed for WIPP analyses

The results of long-term analysis of performance (also referred to as performance assessment) for WIPP were estimated for the first 10,000 years post-closure. Detailed computational models of the WIPP disposal system were used to simulate physical processes starting with repository closure. No drilling intrusions were modeled during the 100-year institutional control period.

Long-term measures of impacts incorporated into the analyses for WIPP disposal alternatives included the following:

- For radioactive substances, the impacts estimated were individual doses (50-year committed dose) expressed as the probability of a latent cancer fatality. The dose was computed for a member of the typically exposed group. The dose reported is the maximum dose received at any time during the first 10,000 years post-closure.

- For carcinogenic hazardous materials, the impacts estimated were probabilities of excess cancer incidence. The exposure was computed for a member of the typically exposed group. The value reported is the maximum exposure rate received at any time during the first 10,000 years post-closure.

- For noncarcinogenic hazardous materials, the impacts estimated as exposures expressed as a hazard index. The exposure was computed for a member of the typically exposed group. The value reported is the maximum exposure rate received at any time during the first 10,000 years post-closure.

H.3.1 Data Sources and Parameter Selection

Data used in the long-term performance analysis were derived primarily from two major WIPP regulatory compliance documents currently under development: the *Draft No-Migration Variance Petition* (Chapter 8 of DOE 1995b) and the DCCA (Chapter 6 of DOE 1995a). In addition, current results from SNL PA calculations supporting the regulatory compliance efforts were used (DOE 1995b), including an on-line database of PA parameters and results of runs of WIPP PA codes.

Values for individual parameters in the computer codes were selected using the following:

- Median values chosen from the statistical distribution defining the parameter

- Seventy-fifth percentile values chosen from the statistical distribution defining the parameter. The value of the parameter was chosen such that it would lead to higher releases than when the median value of the parameter was used.

Although many parameters in the models were employed for the long-term PA, few have a potential impact on the amount of material released. Some of the important parameters include the solubility of contaminants in the waste form, sorption of contaminants on the host salt, hydraulic conductivity of the salt units near the repository, and underground water travel times. Relative to a probabilistic analysis, if (1) these parameters account for most of the variability in the computed release (or risk) values, and (2) values for these sensitive parameters were chosen at the 75th

percentile of their respective distributions, the resulting single output realization would be expected to be within 1 percent of the maximum release statistically possible.

H.3.2 Release Scenarios Analyzed

Two conditions were considered in this study: the undisturbed repository performance and performance under human-intrusion. The undisturbed condition considers the post-closure performance of WIPP for a period of 10,000 years without human contact. Three scenarios were considered under the human-intrusion condition. They included:

- A drilling event that breaches the repository
- A drilling event that breaches the repository and penetrates a hypothetical pressurized brine reservoir in the Castile Formation below the repository horizon
- A mining event that removes potash in units overlying the repository

Analyses of the impacts of each intrusion event are reported as the consequence of a single event and not as the combined impacts from a probabilistic set of drilling events over 10,000 years. The uncertainty inherent in some of the physical parameters that control flow and transport calculations was treated by considering the median and 75th percentile values of the parameters for both undisturbed cases and human-intrusion scenarios.

From a long-term PA perspective, the notable differences among the Proposed Action and Action Alternatives 1, 2, and 3 include their differing inventory loadings, changes in disposal room concentrations of radionuclides and hazardous materials given thermal treatment of the waste, and inventory porosity and permeability changes. The main difference between alternatives is related to the total radionuclide and hazardous material inventory and the repository area (number of panels). Case descriptions for postoperational performance analysis of the Proposed Action and all of the action alternatives are provided in Table H-3.

The same general approach to long-term impacts was used for all cases. The pathways for release and associated models used to quantify flow and transport in the subsurface environment is illustrated in Figure H-1. The system was modeled using BRAGFLO computer simulations of brine and gas flow in the near-repository subsurface environment. The distribution of fluid flow velocities and other quantities obtained from that simulation are then used to drive the NUTS computer code, a subsurface contaminant transport simulator code. Under the current set of PA codes used in the DCCA (DOE 1995a), the SECOTP-2D computer code has been used to model contaminant transport in the Culebra as a two-dimensional system, relying on flow fields calculated by the SECOFL-2D code and potential releases into the Culebra predicted by the NUTS code. However in the analysis, no releases in the Culebra Dolomite using the NUTS code were predicted for both undisturbed and disturbed conditions; thus, the SECOFL-2D and SECOTP-2D codes were not used in SEIS-II.

H.3.2.1 Undisturbed Conditions

For undisturbed conditions (i.e., no human intrusion), the release of radionuclides and hazardous constituents occurs only through dilute aqueous-phase and gas-phase transport from the WIPP repository into the Salado Formation. Waste disposal panels are expected to be nearly close to their final state in 60 to 200 years after decommissioning (Munson 1989). Only near the end of

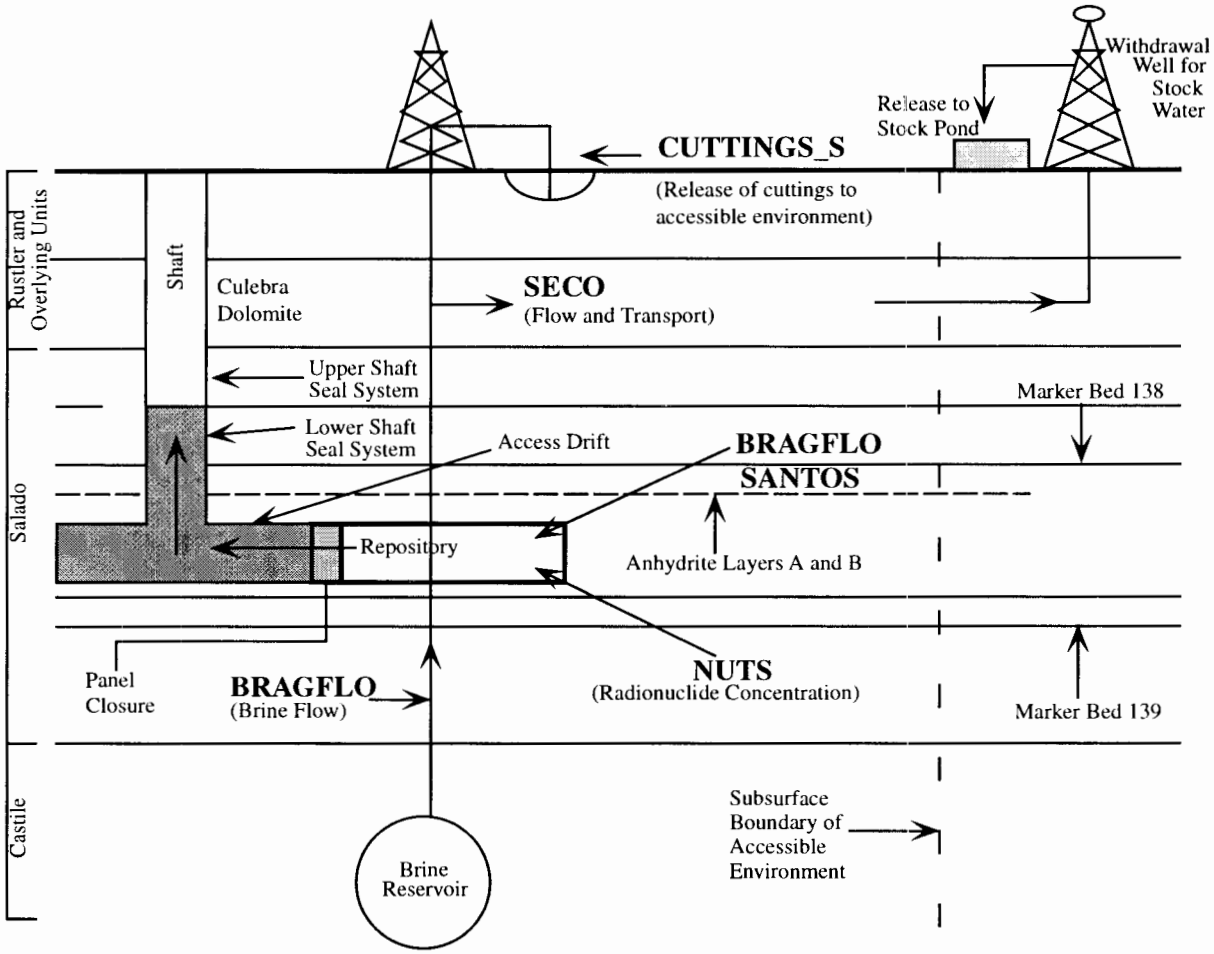


Figure H-1
Schematic Side View of the Repository and Disposal System Associating Major Performance Assessment Codes with Principal Components

Table H-3
Postoperational Performance Analysis of the Proposed Action and Action Alternatives

Alternative	Case Number	Case/Scenario	Data Selection
Proposed Action	1	Undisturbed	Median values
	2	Disturbed (Borehole Intrusion)	Median values
	3	Undisturbed	75th percentile values
	4	Disturbed (Borehole Intrusion)	75th percentile values
Action Alternative 1	6	Undisturbed	Median values
	7	Disturbed (Borehole Intrusion)	Median values
	8	Undisturbed	75th percentile values
	9	Disturbed (Borehole Intrusion)	75th percentile values
Action Alternative 2	11	Undisturbed	Median values
	12	Disturbed (Borehole Intrusion)	Median values
	13	Undisturbed	75th percentile values
	14	Disturbed (Borehole Intrusion)	75th percentile values
Action Alternative 3	16	Undisturbed	Median values
	17	Disturbed (Borehole Intrusion)	Median values
	18	Undisturbed	75th percentile values
	19	Disturbed (Borehole Intrusion)	75th percentile values

Note: Cases 5, 10, 15, and 20 were dropped because backfill was incorporated into the repository design rather than modeled as a mitigation measure.

that period will there be any appreciable resistance from the waste to the closure. The waste is expected to compact to an estimated average final porosity of 15 to 21 percent (Lappin et al. 1989).

H.3.2.2 Disturbed Conditions

Impacts of Drilling into Repository

In this disturbed condition, a hypothetical exploratory drilling operation inadvertently penetrates a waste panel in the repository. As a result, the drilling brings waste originating in the repository to the land surface and exposes individuals involved in the drilling operation to radionuclides and hazardous chemicals. Three separate physical processes (Cole and Simmons 1995) are assumed to influence the quantity of repository waste brought to the ground surface as a result of a drilling intrusion (Figure H-2):

- Cuttings - waste in the cylindrical volume created by the cutting action of the drill bit passing through the emplaced waste.

- Cavings - waste that erodes from the borehole in the response to the upward-flowing drilling fluid within the annulus

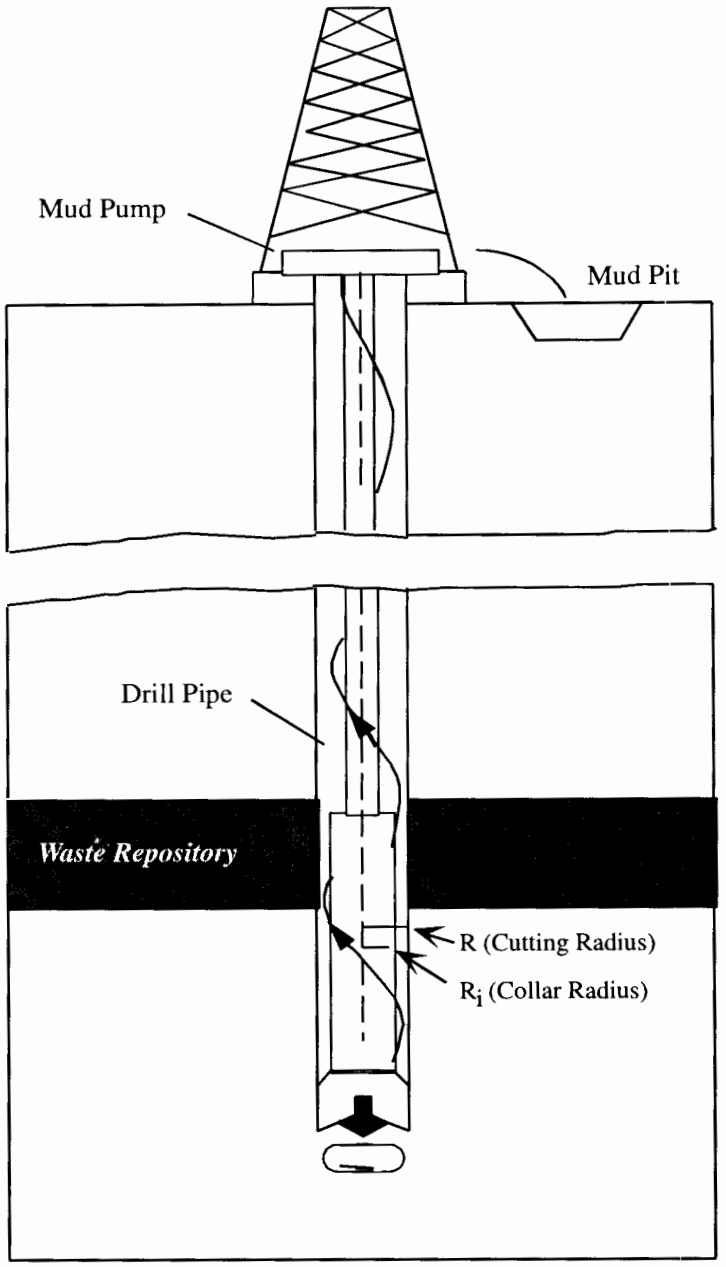


Figure H-2
Illustration of Exploratory Drilling Equipment for Human-Intrusion Scenario

- Spallings - waste and brine introduced into the drilling fluid as a result of the release of waste-generated gas escaping to the lower-pressure borehole. This process requires a repository gas pressure in excess of the hydrostatic pressure of the drilling mud to contribute to the releases.

Radionuclides and hazardous constituents would be released as a result of cuttings and spallings by the mechanical action of the drilling equipment rising to the surface.

The term "waste," as it is used throughout this discussion, includes any backfill or other materials that may have been added to the actual TRU waste material. The spallings method can be subdivided into three regimes that are dependent on the state of waste permeability and gas-pore pressure at the time of the drilling intrusion:

- Blowout - the direct release of waste and contaminated brine to the surface in waste decomposition gas that has cleared the borehole annulus of drilling mud and is flowing freely to the surface

- Gas erosion - low-permeability waste that is pressed against the drill string, as a result of stresses from escaping decomposition gas, and is eroded by the flowing drilling mud

- Stuck pipe - low-permeability waste that is pressed against the drill string sufficiently hard to prevent normal drilling (occurs only at very high gas pressures).

The relationship of repository pressure to the release processes has been quantified and provides the basis for calculations of direct releases of wastes for the CUTTINGS_S computer code, as depicted in Figure H-3. The values of brine and gas pressure in the repository and the permeability of the waste used to determine the release process under this model are obtained from the fluid flow simulations performed with the BRAGFLO computer code. To maximize the impact of repository pressures, simulated brine and gas pressures used were derived for undisturbed conditions calculated for Cases 1 and 3. The calculations of direct releases for the simulated BRAGFLO conditions were carried out using the CUTTING_S code.

The radiological and hazardous chemical impacts were estimated from calculated exposures of two types of individuals involved in the drilling process. These exposed individuals included:

- A member of a drill crew directly involved in the drilling of the exploratory borehole. This individual would be exposed to external radiation from materials at the drill head and in the drill cutting pond and to inadvertent ingestion of small amounts of borehole material releases (100 milligrams per day). The drill crew member was assumed to be exposed to the materials for a period of 168 hours (i.e., 21 working days).

- A well-site geologist involved in the periodic examination of cutting generated by the drilling process. This individual would be exposed to external radiation through the direct handling of an exhumed fragment of waste; thus, only external dose calculations were performed for this exposed individual. The concentration of radionuclides in the exhumed waste fragment was assumed to be the emplacement concentration decayed to the time of intrusion. The geologist was assumed to pick up a cylindrical waste fragment 5 centimeters in radius, with a volume of 524 cubic centimeters. A maximum exposure time of one hour was assumed.

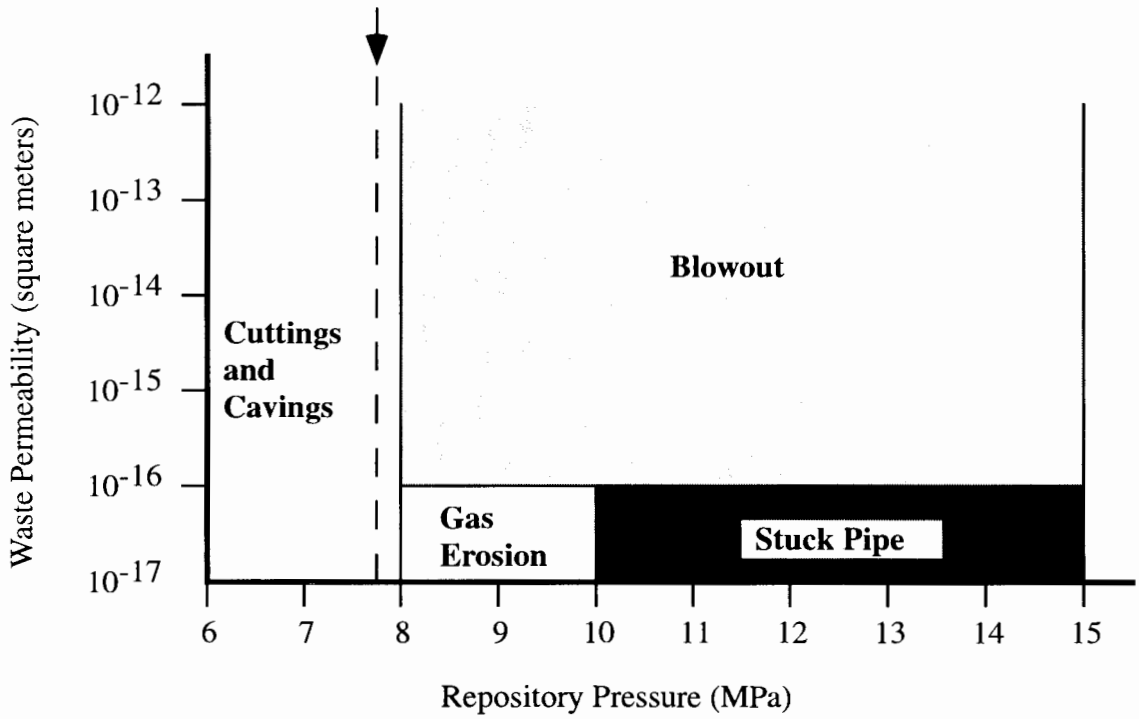


Figure H-3
Release Process Zones for Inadvertent Drilling Intrustion

Radiological impacts were estimated using the GENII computer code. Hazardous chemical (carcinogen and noncarcinogen) impacts were estimated using the MEPAS® computer code. Details of the use of these codes are described in Section H.3.4.

This drilling intrusion was timed to estimate the maximum health impacts to exposed individuals. The earliest time of intrusion was assumed to occur 100 years after repository closure or at the end of the active institutional control period. Because results of BRAGFLO calculations showed a steady increase in brine pressures in the repository (approximately 5 to 14 megapascal) over the initial 2,000 years following repository closure, the potential impact of repository pressure conditions on the release of materials up the borehole was examined. Results of radiological dose calculations for 100 and 1,200 intrusion times demonstrated that, in spite of the predicted increases in repository pressures, maximum impacts were estimated at 100 years. As a result, impact analyses of the drilling intrusion for the Proposed Action (and all other action alternatives) assumed the intrusion occurred at 100 years after repository closure. Some details of this analysis for the Proposed Action are described in Section H.7.1.2.

Drilling in a Pressurized Brine Reservoir Below the Repository

In this disturbed condition, a hypothetical drilling event breaches the repository and penetrates a hypothetical pressurized brine reservoir in the Castile Formation below the repository horizon. For this condition, brine in the reservoir has the potential to come into contact with wastes in the repository and move further up the borehole to more permeable units lying above the repository horizon, like the Culebra Dolomite in the Rustler Formation. Should it occur, such a release to the Culebra Dolomite would then be transported downgradient to a withdrawal well that would pump the contaminated water to the stock ponds used by cattle. Cattle could then become a source of meat consumed by a cattle rancher.

Potash Mining

In this disturbed condition, a hypothetical mining event removes potash in units overlying the repository. The impacts of potash mining on long-term performance of the repository was examined for the Proposed Action only. Regulatory guidance, provided in 40 CFR Part 194 on the assessment of mining events, suggests that long-term compliance analyses of the net effect of mining can be evaluated through off-site impacts of increasing the hydraulic conductivities of key hydrogeologic units. Increasing the hydraulic conductivity of key units would change estimates of groundwater travel time and predicted concentration levels at receptor locations in the accessible environment.

The Proposed Action and the other action alternatives examine the impact of changing the hydraulic conductivity of the Culebra Dolomite, should releases from the repository reach the Culebra in simulations of undisturbed and disturbed conditions of the repository. The Culebra is considered the most significant hydrogeologic unit above potential mined zones and the repository, in terms of off-site transport to the accessible environment. Following guidance provided in 40 CFR Part 194, travel time increases, based on changing the hydraulic conductivity of the Culebra Dolomite by a factor of 1,000, were developed using the areal two-dimensional model of the Culebra implemented in the DCCA (DOE 1996f).

If radionuclides and hazardous metals were to reach the overlying units (like the borehole intrusion scenario), these changes in hydraulic properties could either increase or decrease groundwater travel times to off-site receptor points in the accessible environment. As in the previous scenario,

should such a release to the Culebra Dolomite occur, it would then be transported downgradient to a withdrawal well that would pump the contaminated water to the stock ponds used by cattle. Cattle could then become a source of meat consumed by a cattle rancher.

H.3.3 Source-Term Release and Transport Codes

Computer codes used in this analysis include those currently being used by DOE in the DCCA (DOE 1995a) and in the *Draft No-Migration Variance Petition* (DOE 1995b). A schematic cross section of the repository and the disposal system, associating major PA codes with the principal components of the disposal system they simulate, is presented in Figure H-1. A brief description of each code used is provided below.

H.3.3.1 BRAGFLO

The BRAGFLO code was used to quantify the effects of gas and brine flow on radionuclide transport for undisturbed conditions. The code incorporates the effects of disposal room consolidation and closure, gas generation, and interbed fracturing in response to gas pressurization of the repository. BRAGFLO simultaneously solves partial differential equations that describe the mass conservation of mobile gas and brine components, using appropriate initial conditions, boundary conditions, and other constraints. The important features of BRAGFLO include the following:

- Uses a finite difference approach to simultaneously solve partial differential equations that describe mass and energy conservation of mobile components of gas and brine with appropriate constraint equations, initial conditions, and boundary conditions

- Simulates a porous medium that can be occupied by brine, gas, or both brine and gas where the brine and gas are assumed to be immiscible

- Considers formation permeability simulations to be anisotropic

- Uses relative permeability and capillary pressure equation models available, including van Genuchten-Parker, original Brooks-Corey, and modified Brooks-Corey (Appendix BRAGFLO in DOE 1995a)

- Calculates the overall movement of gas and brine in the disposal unit and surrounding formations and defines the flow fields for contaminant migration postprocessing codes

- Contains the submodels for estimating gas generation in the repository, disposal room closure and consolidation, and interbed fracturing

- Simulates gas generation by creating gas in the waste disposal panels from the corrosion of waste containers and by microbial degradation of cellulose materials in the disposed wastes

- Changes in permeability and gas-storage volume of the waste resulting from creep closure are coupled to BRAGFLO through SANTOS, a code that provides a "porosity surface" used as a reference to track changes in room volume. SANTOS results are included in BRAGFLO through a series of tables that provide data to BRAGFLO describing dynamic changes in porosity as a function of time and pressure

- Allows fracture treatment for pressure-induced alterations to material porosity by introducing a pressure-dependent compressibility using a piecewise linear rock compressibility function

- Includes boundary conditions such as (1) Dirichlet (constant pressure), (2) inhomogeneous Neuman (fixed-pressure gradient), and (3) mixed boundaries (mix of Dirichlet and Neuman). For this analysis, a no-flow boundary condition is used for all exterior grid boundaries except at the far-field boundaries of the Culebra and Magenta Members and the top of the grid (i.e., the surface ground). The boundaries of the Culebra and Magenta are assigned constant pressure conditions used in those Members. The ground surface elements are maintained at 1 atmosphere (Appendix BRAGFLO in DOE 1995a).

For detailed information of the governing equations, initial and boundary conditions, and submodels used by BRAGFLO, refer to the DCCA (Appendix BRAGFLO of DOE 1995a).

H.3.3.2 NUTS

The NUTS code was used to track brine that has been in contact with waste in the repository. NUTS uses the calculated gas and brine flow fields computed by BRAGFLO to transport the radionuclides in solution in the brine from the repository into the surrounding halite and anhydrite beds of the Salado Formation. These calculations also include the transport of radionuclides up a borehole or repository shaft to determine the quantity of radionuclides that could potentially reach the overlying Culebra Dolomite of the Rustler Formation. The important features of NUTS include the following:

- Uses finite difference techniques to simulate the decay and transport of multiple radionuclide components in three dimensions in fractured or unfractured media. Simulations can be performed using single-porosity, dual-porosity, and dual-permeability models.

- Simulates transport of both radioactive and nonradioactive contaminants

- Considers transport of radionuclides with chain decay

- Simulates sorption using three different sorption isotherms: linear, Freundlich, and Langmuir equilibrium isotherms

- Considers transport with solubility limits of individual contaminants and their precipitation. The precipitate can be decayed or redissolved in calculated concentrations that drop below solubility limits.

- Considers transport with multiradioactive site representations, a variety of source and sink terms, and the implementation of temperature dependency of certain parameters (temperature-dependent solubility, molecular diffusion, and sorption). The transport of contaminants in the gas phase can also be considered.

For more information regarding the underlying theory, governing equations, initial and boundary conditions, and submodels used by NUTS, refer to the DCCA (Appendix NUTS of DOE 1995a).

H.3.3.3 CUTTINGS_S

The CUTTINGS_S code was used with the results calculated by BRAGFLO to determine radionuclide releases to the land surface by inadvertent repository intrusion by an exploratory borehole. CUTTINGS_S estimates the effect of separate physical processes that can influence the quantity of wastes brought to the ground surface by an exploratory borehole. These processes are:

- Generation of cuttings - wastes in the cylindrical volume created by the cutting action of the drill bit
- Cavings - wastes that erode from the borehole wall in response to the upward-flowing drilling fluid within the borehole annulus
- Spallings - wastes introduced into the drilling fluid by the release of waste-generated gas escaping into the lower-pressure borehole
- Blowout - wastes introduced into the drilling fluid by the release of a large volume of gas originating from decomposed wastes

CUTTINGS_S is also capable of estimating the effects of other less-likely processes, such as the creation of brine spalls and slurries that could also potentially bring wastes to the ground surface.

For more information regarding the underlying theory, governing equations, and utilities used by CUTTINGS_S, refer to the DCCA (Appendix CUTTINGS_S of DOE 1995a).

H.3.4 Dose and Exposure Codes

The potential health impacts from exposure to radioactive material and hazardous, nonradioactive material releases from WIPP were evaluated using two computer codes. The potential health impacts included (1) direct and indirect exposure to radioactive and hazardous materials at the top of an exploratory borehole that penetrates the repository or a pressurized brine pocket below the repository and (2) direct or indirect exposure to radioactive and hazardous materials in a stock well that receives waters from the Culebra Member of the Rustler Formation that has been impacted by the exploratory borehole or other human-intrusion actions.

H.3.4.1 GENII

The GENII code package was used to obtain the following calculations: a maximum lifetime dose from radioactive material over 10,000 years for potential acute and chronic releases (Napier et al. 1988a, 1988b, 1988c); detailed doses for a single lifetime over 10,000 years; and doses resulting from direct exposure, ingestion, and inhalation of radioactive material. Determination of individual doses used a 50-year commitment model for acute and chronic exposures.

H.3.4.2 MEPAS®

The MEPAS® code evaluates transport and exposure pathways for chemical and radioactive releases according to their potential human health impacts. MEPAS® is a physics-based code that brings together contaminant release, migration, and the fate of environmental media (including groundwater, surface water, air, or soil) with exposure routes (including inhalation, ingestion,

dermal contact, or external dose) and health consequences for radiological and nonradiological carcinogens and noncarcinogens.

The exposure model was the only MEPAS® module used in the long-term analyses. Results from the different transport pathway models are used to calculate the human health impacts for nonradiological contaminants. The exposure model considers potential exposure of individuals and the surrounding population through the following exposure routes: (1) external dermal contact, (2) inhalation of airborne contaminants, and (3) ingestion of contaminated drinking water, soil, crops, animal products, and aquatic foods. Each exposure route is evaluated for the estimated average daily human exposure from each contaminant. These daily exposure rates are then converted to an average individual risk factor, using mathematical codes for radionuclides, carcinogenic chemicals, and noncarcinogenic chemicals.

The risk factor is intended to indicate the level of potential human health impact to a maximally exposed individual or an average member of the exposed population over a 70-year lifetime. The risks from chemical carcinogens are currently based on cancer potency factors defined in the U.S. Environmental Protection Agency's (EPA) *IRIS: Integrated Risk Information System* (EPA 1995b). Impact estimates for noncarcinogenic chemicals are based on reference dose levels, as defined in IRIS (EPA 1995b).

The resulting human health impacts are individual 70-year averages for each exposure route, for each receptor point, and for each contaminant. The resulting 70-year impacts are the lifetime cancer incidence for carcinogenic chemicals and the hazard quotient for noncarcinogenic chemicals.

H.4 CONCEPTUAL MODEL OF THE DISPOSAL SYSTEM

Existing conceptual models of the WIPP disposal system developed for regulatory compliance analysis in the *Draft No-Migration Variance Petition* (DOE 1995b) and DCCA (DOE 1995a) provided the basis for the SEIS-II analysis of long-term performance. The following is a synopsis of key conceptual models of the disposal system drawn from these compliance documents.

The disposal system is defined as the combination of engineered and natural barriers that isolate disposed waste from events and processes that are capable of affecting isolation of the waste. The key feature of the disposal system is the Salado Formation which provides a critical natural barrier to contaminant migration from the repository. The engineered barrier system includes materials emplaced as backfill as well as the seal closures installed in drifts, shafts, and boreholes. The following overview of the conceptual model covers some of the principal aspects of the disposal system assumed for this analysis. A summary of critical assumptions regarding brine and gas migration, taken from the *Draft No-Migration Variance Petition* (DOE 1995b), is provided in Table H-4.

H.4.1 Repository System

The repository system contains a number of key elements that contribute to its overall long-term performance. Brief descriptions of these elements are described in subsections H.4.1.1 to H.4.1.7.

Table H-4
Partial List of Brine and Gas Migration Modeling Assumptions

General Assumptions	Brine and gas flow fields are based on a single geometry and deterministic (expected performance value) selection of material properties.
	Two-phase flow (brine and gas) obeys Darcy's law for compressible fluids in all media. Phases are pure components; the Brooks-Corey two-phase equation is used to describe two-phase flow.
	Pore space is fully connected in all regions.
	Prior to excavation, the Salado Formation is in hydrostatic equilibrium (i.e., no gradients exist in the Salado). After excavation, brine flow is induced by repository effects.
	Gas has the composition and physical properties of hydrogen.
	All liquid possesses properties of Salado brine.
	Gas does not dissolve in brine.
	Initial conditions - waste panels remain open for 5-year waste emplacement period.
	Hysteresis effects are assumed to be negligible.
	For purposes of numerical modeling, the model domain extends 22.4 kilometers (14 miles) from the repository and extends upward from the base of the Salado to the surface. With the exception of the Culebra Dolomite boundary, no flow normal to the boundary is assumed. Constant pressure and saturation conditions are applied at the model domain boundary of the Culebra and along the surface.
	Pressure is specified in hydrostratigraphic units overlying the Salado.
	Klinkenburg effect is included.
	At pressures near lithostatic or in excess of lithostatic, the surrounding formation will deform. Pressure conditions exceeding lithostatic conditions are not stable.
	Grid dimensions associated with all regions (e.g., shaft, waste disposal panels, etc.) are preserved and do not change with time.
Anhydrite and Halite Assumptions	There is simplified stratigraphy with two lithologic types: anhydrite and impure halite.
	Anhydrite interbeds are MB 138, combined A&B, and MB 139 only.
	Post-closure brine inflow from clay consolidation is negligible.
	Pressure-dependent fracturing occurs at near-lithostatic pressure, modeled with pressure-dependent permeability and porosity.
	One degree uniform dip to the south.
	Gas does not penetrate impure halite because of its high threshold pressure (P_t).
	Initial (pre-excavation) impure halite and anhydrite porosity specified; varies with pressure because of compressibility.
	Permeabilities, porosities, and Salado brine saturation are adjusted in the excavation at time $T_0=0$ for the 10,000-year simulation (e.g., at repository closure). Initial Salado brine saturation specified as fully saturated.
	Impure halite permeability specified constant in time.
	Intact anhydrite permeability initially spatially constant.

Table H-4
Partial List of Brine and Gas Migration Modeling Assumptions-Continued

Disturbed Rock Zone	Permeability specified and constant during operational phase. For initial model conditions, operational DRZ becomes partially desaturated and depressurized.
	At $T_0=0$, DRZ is assigned time-invariant, high permeability (DRZ does not heal).
	Threshold capillary pressure is zero.
	At $T_0=0$, porosity is specified as impure halite.
	Initial conditions - brine saturation specified as fully saturated; variation calculated during operational phase as brine flows in and drains out.
	Initial pressure in hydrostatic equilibrium with rest of Salado.
Waste/Disposal Region Assumptions	Radially flaring, two-dimensional geometry; all pillars are removed from panels, resulting in homogeneous waste region.
	Initial conditions - empty cavity; very high permeability, porosity equals 1.0; pressure equals atmospheric.
	Waste and panel closures are emplaced simultaneously: at $T_0=0$, waste region and panel closures are assigned constant permeability of unconsolidated waste with no backfill and panel closures are assumed ineffective in long-term sealing.
	Porosity and pore volume of waste region vary with creep closure, which is a function of time-dependent gas generation, fluid movement, and repository pressure.
	Wicking of brine occurs through capillary forces and results in increased contact of brine and waste.
	Pressure at $T_0=0$ is atmospheric; Salado brine content at end of operational period is discarded to reflect removal during ventilation. The representative moisture content of emplaced waste is used to specify the initial brine saturation of the waste region.
	Threshold capillary pressure is zero.
Gas Generation	Two gas-generation processes are assumed to occur and proceed independently of one another; anoxic corrosion and microbial degradation of all cellulosics, plastics, and rubbers.
	In the average-stoichiometry model, rates of gas generation by corrosion and microbial generation change, depending on brine saturation of waste region.
	Brine is consumed by corrosion but is neither consumed nor produced during microbial degradation.
	If brine saturation equals zero in a cell, gas generated by anoxic corrosion and microbial degradation ceases.
	If brine is present, gas continues to be generated on a cell-by-cell basis until all reactant inventories are depleted.
Shaft Seal Design	Highly compacted crushed salt barrier and clay barriers provide long-term seal.
	Short-term seals (concrete and asphalt) limit short-term brine inflow and retard short-term gas migration.
	Porosity of shaft seals and intervening shaft regions is constant at consolidated levels.
	Effective permeability of shaft regions varies with time in a stepwise fashion to reflect consolidation.
	Time-varying DRZ properties are included in the effective permeability of the adjacent shaft components.
	Permeability of concrete shaft seal components degrades to that equivalent to silty sand.
Contaminant Migration	Gas-phase organic compounds mix with waste-generated gas and are transported simultaneously as a single gas having the physical properties of hydrogen gas.
	Gas and brine are immiscible and, everything else equal, the gas phase is more mobile than the brine phase.
	Hazardous constituent metals dissolved in brine and organic constituents partitioned into the brine phase are transported simultaneously.
	A surrogate metal tracer is transported, assuming only advective and dispersive processes. No credit is taken for retardation through sorption to fixed substrates within the repository or along migration pathways (mobilized metals will likely be adsorbed to waste forms, clays and anhydrites, or engineered components of the disposal system, (e.g., clay in shaft seals).

H.4.1.1 Salt Creep

Salt creep is an important process in the conceptual model of the disposal system. It occurs naturally in Salado Formation halite in response to deviatoric stress created by the excavation of the repository. Closure of the waste disposal panels by salt creep will eventually consolidate waste in the disposal areas until an equilibrium with the surrounding rock is reached. The shaft and repository excavation have resulted in a system of fractures caused by stress relief within the salt; these fractures, which surround the shaft and excavation, create what is referred to as a DRZ. The DRZ will develop within the Salado Formation around shafts connecting the repository to the surface. The process of salt creep will partially heal fractures in the Salado Formation halites, leading to a general reduction in the overall permeability and porosity within the DRZ over time.

H.4.1.2 Brine Flow

Pressure gradients created by the excavation of the repository will cause brine in the surrounding rocks to flow into the waste disposal panels. Brine flow into the repository decreases as the repository pressure increases, as a result of the generation of gas from waste degradation. Brine will be expelled from the repository if pressure in the repository exceeds the brine pressure in the surrounding rock.

H.4.1.3 Gas Generation

Gases such as hydrogen gas, carbon dioxide (CO_2), and methane will be generated as waste stored in the repository comes into contact with inflowing brine and degrade via a variety of chemical and microbial processes. These processes are expected to degrade metals, cellulose and similar materials (cellulosics), and plastics and rubber materials contained within the disposed waste. The dominant gas-generating processes are anoxic corrosion of ferrous metals in the waste and waste containers and the microbial degradation of cellulosics, plastic, and rubber in the waste. In general, as gas pressure rises as a result of repository closure and gas generation, increased pressure will impede creep closure and consolidation of the waste region. Gas generation is expected to cause fracturing or increase the porosity of existing fractures of anhydrites beyond the DRZ as repository pressures approach or exceed lithostatic levels.

H.4.1.4 Source-Term Release Mechanisms

As rooms and access drifts are closed by the process of salt creep, waste containers will be crushed and breached. In the absence of backfill which would slow this process, the chemical conditions in the post-closure environment would rapidly become reduced (anoxic) as oxygen is consumed by initially oxic reactions, as gas is generated by waste degradation, and as brine fills the void volume in the waste disposal region. Radioactive and hazardous constituents would be released as waste drums are breached and waste comes into contact with brine and gas. For liquid-phase contaminants to be generated, sufficient brine inflow must occur to dissolve the waste constituents in the solid phase or serve as a medium for partitioning of vapor-phase organics into the brine. Furthermore, repository conditions (pressure and temperature) and chemical conditions (pH and Eh) must be suitable to dissolve and mobilize metals existing as elemental metals or salts. For this SEIS-II analysis, as in the *Draft No-Migration Variance Petition* (DOE 1995b) and the DCCA (DOE 1995a) analyses, it was conservatively assumed that instantaneous dissolution of waste containers and immediate mobility of radioactive and hazardous constituents in the gas and liquid phases at WIPP closure would occur.

H.4.1.5 Dilation and Fracturing of the Anhydrite Interbeds

Gas generated by waste degradation approaching or exceeding lithostatic pressure is expected to fracture the anhydrite interbeds and dilate the existing fractures in the vicinity of the repository. This will enhance flow and mass transport of contaminants. Potential transport processes within the fractured interbeds include advection, diffusion, dispersion, fracture-matrix flow, channeling and fingering, retardation, and sieving. Mass transport in gas and brine flow in unfractured anhydrite beds is possible; however, because of their low permeability, transport in these beds is not likely to be important.

H.4.1.6 Repository Features

The reference design of the repository under the Proposed Action contains 10 panel equivalents. Each panel consists of seven disposal rooms and connecting access drifts. These areas will be sequentially filled with waste and then sealed. The repository size for Action Alternatives 1, 2, and 3 are 68, 75, and 71 panel equivalents, respectively. The repository size is embedded in the grid geometry for BRAGFLO runs that simulate brine and gas flow in the repository and surrounding region.

H.4.1.7 Engineered Components

Current plans make use of cylindrical seals, consisting of salt columns interleaved with concrete plugs, clay, and other engineered materials, to seal the repository access drifts and shafts from inflowing groundwater reduce the migration of contaminants through the repository and shaft system. The seals will be emplaced in the four shafts connecting the repository to the surface.

The Department also plans on using a magnesium oxide backfill to provide chemical control over the solubility of radionuclides in the post-closure repository environment, in compliance with the requirements of 40 CFR Part 191. Long-term performance calculations for the Proposed Action include the effects of the magnesium oxide backfill. Actinide solubility in the repository is highly dependent on the pH, conditions and the oxidation state of the actinide. Gas generation resulting from microbial degradation of carbon in waste materials is expected to generate CO_2, lower pH, and generate carbonate species that bind very strongly to actinides, as complexes, to form relatively highly soluble actinide species. The presence of appropriate amounts of magnesium oxide is expected to react with brine that may reach the repository and any CO_2 gas generated as a result of microbial action to maintain a sufficiently high pH and minimize the formation of carbonate complexes that result in higher actinide solubilities. More details on the theory behind the current plans for this backfill are described in Appendix D22 of the *Resource Conservation and Recovery Act Part B Permit Application* (DOE 1995c).

H.4.2 Salado Formation

The Salado Formation is the principal natural barrier to fluid flow between the repository and the accessible environment. For the purpose of this analysis, the Salado is conceptualized as a porous medium composed of several rock types arranged in layers, except in the vicinity of the repository where stress-relief fractures have disrupted the continuous layers. Near the repository, the DRZ in the Salado is conceptualized as a zone of increased permeability and porosity, offering little resistance to flow between the repository and the surrounding rocks. The intact Salado consists of sequences of two rock types, impure halite and anhydrite. These rock types are assumed to be a homogeneous porous medium with spatially constant properties. Specific information and model

inputs used in this analysis to represent the major rock types and the DRZ in the numerical models of the repository are summarized in Section H.6.

H.4.3 Units Above and Below the Salado Formation

Elements of the disposal system model conceptualized above and below the Salado Formation include units within the Rustler Formation, the Dewey Lake Formation (also called the Redbeds) and supra-Dewey Lake units, and the Castile Formation with associated brine reservoirs. Brief descriptions of each of these elements are provided below.

H.4.3.1 Rustler Formation

The Rustler Formation is conceptualized as having five recognized members: the unnamed lower, the Culebra Dolomite, the Tamarisk, the Magenta, and the Forty-Niner. The unnamed lower member of the Rustler Formation is characterized by relatively low transmissivity. For the purpose of this analysis, this unit is treated as an impermeable unit.

The Culebra Dolomite is conceptualized as the most permeable unit within the Rustler Formation and, therefore, the most notable unit in the long-term release to the accessible environment. It may be possible for radionuclides and other hazardous constituents to travel up the sealed shafts, through gas or brine flow, into the Culebra as a result of high repository pressure. Gas and/or brine flowing up either exploratory boreholes that have penetrated the repository or deeper pressurized brine pockets below the repository could also be introduced into the Culebra.

Human-intrusion scenarios may introduce gas into the boreholes either from such sources as the Castile Formation brine reservoirs or from gas in the repository generated in the waste. Because of the lower pressures in the units above the Salado Formation, the gas volume will expand over the volume occupied in the reservoir. Gas bubbles could alter the natural flow patterns and velocities of the brine because of flow blockage and density differences, and the gas bubbles could migrate differently than the brine. Fracture-matrix flow could be considerably changed with the introduction of gas as a result of capillary pressure difference between the phases, possibly resulting in gas flow primarily in fractures and brine flow restricted to the matrix. Chemistry could also be changed by the introduction of gas into the non-Salado Formation units. For the purpose of this analysis, the Culebra Dolomite was analyzed using single-phase or fully saturated approaches for flow and transport, assuming that two-phase conditions associated with gas release do not substantially impact transport calculations.

According to Axness et al. (1995), an intrusion borehole connecting the Culebra with the Salado and a Castile brine reservoir could allow brine to flow into the Culebra which, in turn, could cause hydraulic head in the Culebra to increase, locally inducing radial flow from the borehole. The area affected would depend on the transmission and storage capabilities of the Culebra, and on the flow rate into the Culebra. The study by Reeves et al. (1991) indicated that, for much of the range of brine reservoir and breach borehole parameters, the fluid disturbance created in the Culebra by the borehole had minimal impact on the flow field. In addition, transport calculations under these conditions need not include the transient impact of locally increased hydraulic head near the breach borehole. This study also found that, for extreme conditions at the high end of the brine reservoir volume, pressure range, and borehole permeabilities, travel time for a conservative solute can be reduced by as much as 7.4 percent because of increased heads in the vicinity of the borehole. This effect can be implemented in an undisturbed flow field by increasing hydraulic heads in the vicinity

of the borehole. The fluid from an intrusion borehole could have the following four effects on flow and transport in the Culebra:

- Increase in hydraulic gradients and flow velocities in the vicinity of the borehole
- Change in the density of the Culebra fluid
- Result in rock/water interactions that locally alter flow and transport properties in the Culebra
- Result in local multiphase flow conditions in the Culebra

For the purpose of this analysis, SEIS-II did not consider any of these specific processes in analyzing the impacts of a borehole intrusion on the Culebra.

If radionuclides reach the Culebra, they may be transported to off-site receptors from the point of introduction by groundwater flowing through the Culebra. Radionuclide transport in the Culebra is represented in this analysis by two-dimensional flow through a horizontal, confined aquifer containing fractures and spatially variant transmissivity.

According to Axness et al. (1995), the Culebra Dolomite is a double-porosity medium at some locations on and around WIPP. Double-porosity simply means that the Culebra has a porosity attributable to its rock matrix and another attributable to fractures. Allowing flow and transport in fractures within the Culebra generally overestimates transport in those areas where the Culebra has a low transmissivity and has been interpreted as a single-porosity, matrix-only medium. In a double-porosity, fractured medium, flow is generally conceptualized as occurring primarily in the fractures, because flow velocities are usually orders of magnitude higher in the fractures than in the matrix. However, the process of diffusive (or advective) transport of radionuclides or contaminants from fractures into the matrix can physically retard these substances.

For the purpose of this analysis, SEIS-II has adopted the conceptual model for Culebra flow and transport used in previous WIPP PAs. The double-porosity conceptualization used in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) and, more recently, in the DCCA (DOE 1995a) analyses assume that advective transport occurs only in fractures, with diffusion of radionuclides and other contaminants occurring between the fractures and matrix.

Interactions of brines containing radionuclides and hazardous contaminants with the Culebra Dolomite and, in particular, clay mineral linings on fracture surfaces have been postulated as having the potential to cause chemical retardation. Because of the lack of technically defensible experimental evidence to support these processes at the scale of interest, the impacts of chemical retardation are not being considered in current PAs. To bound transport calculations used in this analysis, SEIS-II did not consider the effects of chemical retardation for contaminant transport in the Culebra. The reader is referred to Axness et al. (1995) for more detailed discussions of this topic.

The Tamarisk Member rests between the more transmissive Culebra Dolomite and Magenta Dolomite Members of the Rustler Formation. Like the unnamed lower member, the Tamarisk Member does not have a high transmissivity. For the purpose of this analysis, this member was treated as impermeable.

Although the Magenta Dolomite Member is transmissive, transport of radionuclides within this unit was not considered because it has been shown that radionuclides within the Magenta will not reach the site boundary in 10,000 years (Barr 1983).

Because of its low permeability, the Forty-Niner Member is considered to be relatively unimportant for flow and transport analysis (Beauheim [1986] and Beauheim et al. [1991]). For the purpose of this analysis, the Forty-Niner Member is considered impermeable.

H.4.3.2 Dewey Lake (Redbeds) Member and Supra-Dewey Lake Units

The Dewey Lake (Redbeds) Member is conceptualized as having a low permeability compared to that of the Culebra Dolomite Member. Because of the high adsorptive capacity of the redbeds, transport of radionuclides in this member is assumed to be negligible.

For the purpose of this analysis, all units above the Dewey Lake (Redbeds) Member, the Gatuna and Santa Rosa Formations, were assumed to behave as a single hydrogeologic unit of relatively high permeability.

H.4.3.3 Castile Formation and Brine Reservoirs

The Castile Formation is postulated to have a very low permeability because of its evaporite content. However, brine under high pressure has been encountered in the Castile Formation (the WIPP-12 borehole) within the disposal system boundary and the U.S. Energy Research and Development Administration borehole number 6. The connection of a brine reservoir in the Castile with the waste panels at the repository level and overlying units by an exploratory borehole has been postulated as a possible human-intrusion scenario.

H.5 CONCEPTUAL MODEL OF THE SOURCE-TERM RELEASE

TRU waste is packaged at the generator-storage sites in a primary confinement barrier (i.e., metal drum or container). The packaging may include several internal barriers: layers of plastic; plastic, metal, and glass containers; and adsorbents in the void spaces. Volatile organic compounds (VOC) and semivolatile organic compounds are present within solidified liquids and sludges and in trace quantities sorbed onto cellulosics and other solid waste materials. A VOC gas/vapor phase dominates void spaces within the container and within the inner layers of confinement. Hazardous constituent metals, including lead from rubber gloves and shielding, will exist in the solid phase. Other regulated metals may occur as trace contaminants in soil, debris, sludges, and solidified liquids and as components of metal tools, equipment, and machinery. WAC and other DOE efforts are designed to preclude the presence of free liquids; therefore, a large initial liquid phase is not a feature of the conceptual model. Conceptually, the hazardous constituent liquid phase results from brine inflow and waste dissolution in the closed repository.

DOE has considered the potential effects of a number of possible chemical and thermal processes in the disposal system environment. These processes include corrosion, microbial activity, radiolysis, dissolution reactions, reactions with cementitious materials, and adsorption/desorption. These processes can either immobilize radioactive and hazardous constituents or enhance mobility. For practical purposes, an insufficient amount of information is known about many long-term chemical processes in the WIPP environment to model accurately the potential effects on each of these processes. In cases where information is limited, conservative assumptions are made to overestimate the source-term radioactive and hazardous constituent mobility.

H.5.1 Key Assumptions for Source-Term Release

The assumptions presented below on the source-term conceptual model used in the SEIS-II analysis are consistent with many on the assumptions on the source-term release conceptual models used in the *Draft No-Migration Variance Petition* (DOE 1995b) and DCCA (DOE 1995a).

- Corrosion of waste containers and dissolution of all radioactive and hazardous constituents may occur instantaneously; if so, contaminants in the gas and liquid phases would be mobile at repository closure. This is a conservative assumption, because the pressure, temperature, and chemical conditions (such as pH and Eh) may not be sufficient to completely dissolve and mobilize radioactive and hazardous constituents. It is also conservative because a number of time-dependent mechanisms would decrease the initial source-term concentrations for organic and metal constituents.

- Some radioactive constituents are mobilized either by dissolution in brine as intrinsic colloids or by adsorption onto colloidal particles carried by the brine. Such constituents exist primarily in the liquid phase, decrease by processes of radioactive decay, and evolve to other daughter products by the process of chain decay. For the purpose of this analysis, solubility-controlled releases of key actinides were considered but adsorption processes were not. This is a conservative assumption, because adsorption will retard the near-field release and transport of radioactive constituents. Colloids and organic-complexing agents capable of enhancing or inhibiting hazardous constituent mobility and transport are not modeled because of a lack of waste-specific and repository-specific information.

- Hazardous constituents exist in each phase in the waste disposal panels at constant concentration over time. This is a conservative assumption, because it assumes an infinite source and complete persistence. In reality, however, some metals and organics will migrate from the source-term region and organics will likely degrade.

- Migration of hazardous constituents from the repository does not decrease the initial source-term concentration. In reality, however, some hazardous constituents will migrate away from the waste disposal panels and the source term should decrease with time.

- The waste-loading strategy for both contact-handled (CH) and remote-handled (RH) TRU wastes limits the heat-generation rate to less than 24 kilowatts per hectare (10 kilowatts per acre) (DOE 1995c). At this level, heat generation is expected to have inconsequential effects on flow and transport processes and are not considered in this analysis.

For more details of the conceptual model for source-term release, see the *Draft No-Migration Variance Petition* (Chapter 8 of DOE 1995b) where model descriptions for the gas-phase and liquid-phase source-term are provided.

H.5.2 Screening of Key Contaminants

A large number of radionuclides, VOCs, and hazardous materials are contained in the waste to be emplaced in WIPP. Screening analyses were performed on key contaminants, in order to focus the long-term PA activities on those constituents expected to have the highest contribution to risk. The inventory on which these analyses were performed is described in Appendix A. These analyses differed from those performed for the DCCA (DOE 1995a) or the *Draft No-Migration Variance Petition* (DOE 1995b).

H.5.2.1 Selection of Radionuclides

The first screening examined the relative contribution to radiation dose from the radionuclides in WIPP based on their ability to mobilize in water. A total of 52 radionuclides were evaluated. The approach was to determine the radionuclide concentration in water and then calculate the dose obtained from drinking 2 liters (one-half gallon) of contaminated water. The solubilities for each element were taken from published PAs (SNL 1992); if the solubility was not available in published literature, a value of 1×10^{-6} molar was used. The amount of water available for dissolution was assumed to be the repository volume adjusted for a waste and backfill porosity of 0.25. The amount of radionuclide going into the solution was limited to its total inventory. The relative contribution to radiation dose from radionuclides at both 100 and 1,000 years post-closure are given in Table H-5. The list of important radionuclides is more dependent on the inventory and, thus, on concentration in the water than on the solubility. Moderate changes in the solubilities would probably yield the same list of important radionuclides.

All radionuclides are expected to migrate slowly under undisturbed repository conditions. In addition, it is assumed that institutional controls would be in place for 100 years after the repository is closed, and no exposure to radionuclides would be expected. Therefore, the risk screening was performed using the inventory at 100 years post-closure rather than using the emplaced inventory.

The radionuclide half-life was also considered in the selection process. For instance, cobalt-60 (Co-60) has a 5.26-year half-life. Although over 50,000 curies (Ci) of Co-60 may be emplaced in the waste form, it will have decayed to a small amount within 100 years. Therefore, radionuclides with a short half-life and no parent radionuclide in the inventory were eliminated from consideration.

Another consideration for screening was the inventory of the different radionuclides. Those with the highest inventory (in Ci) for Action Alternative 1 are shown in Table H-6.

The list of radionuclides included in this analysis was developed with the nine having the highest inventory: plutonium (Pu)-238, Pu-239, Pu-240, Pu-241, americium (Am)-241, cesium (Cs)-137, barium (Ba)-137m, yttrium (Y)-90, and strontium (Sr)-90. Y-90 and Ba-137m were subsequently dropped from the list because of their short half-life; however, their impacts are included in the reported dose values because the dose factors used for Sr-90 and Ba-137m include the decay energies of Y-90 and Ba-137m. Based on the relative risk from water mobilization, actinium (Ac)-227, protactinium (Pa)-231, uranium (U)-233, U-234, curium (Cm)-243, Cm-244 and lead (Pb)-210 were then added to the list.

Therefore, the following radionuclides were used in the long-term PA analyses: Ac-227, Am-241, Cs-137, Cm-243, Cm-244, Pa-231, Pb-210, Pu-238, Pu-239, Pu-240, Pu-241, U-232, U-233, U-234, Sr-90, and Y-90. For impacts beyond 100 years, essentially all of the Cm-243 and Cm-244 will have decayed into Pu-239 and Pu-240, respectively. A total of 30 radionuclides were carried in several decay chains in the computer codes NUTS and CUTTINGS_S to maintain correct inventories of the chosen radionuclides.

Table H-5
Relative Radionuclide Contributions to Risk for the Water Mobilization Screen

100 Years		1,000 Years	
Radionuclide	**Percent Risk**	**Radionuclide**	**Percent Risk**
Sr-90	72.2	Ac-227	32.6
Cs-137	7.7	Pa-231	26.4
U-233	6.5	U-233	21.3
Cm-244	3.0	Pu-238	6.5
Cm-243	2.9	U-234	3.9
Pu-238	2.0	Am-241	2.6
Ac-227	1.1	Ra-225	2.3
Pa-231	1.1	Ra-223	1.3
U-234	0.9	Pb-210	1.0
Am-241	0.8	Ac-225	0.7
Pb-210	0.4	Po-210	0.3
Pu-241	0.3	Ra-226	0.2
U-232	0.2	---	---

Table H-6
Radionuclides with Highest Inventories (Ci) for Action Alternative 1

CH-TRU Waste		RH-TRU Waste	
Radionuclide	**Inventory (Ci)**	**Radionuclide**	**Inventory (Ci)**
Pu-241	2,623,553	Cs-137	1,085,025
Pu-238	2,413,581	Y-90	1,056,299
Pu-239	923,975	Sr-90	1,056,096
Am-241	575,924	Ba-137m	1,026,566
Pu-240	204,657	Pu-241	706,676
Y-90	8,937	Co-60	52,221
Sr-90	8,935	Pu-239	51,455
Cs-137	7,045	Am-241	29,911
Cm-244	6,843	Pu-240	25,318
Ba-137m	6,664	Pu-238	7,509
U-233	4,019	Eu-152	7,308
Pu-242	1,550	Eu-154	3,550

H.5.2.2 Selection of VOCs

Laboratory sampling results for VOCs in 930 drums of CH-TRU waste from the Idaho National Environmental Laboratory (INEL) and Rocky Flats Environmental Technology Site (RFETS) were published in the *Draft No-Migration Variance Petition* (DOE 1995b). A number of the reported constituents with the highest health impacts were included in the accident analyses performed for SEIS-II: carbon tetrachloride, chlorobenzene, chloroform, methyl ethyl ketone, methylene chloride, 1,1,2,2-tetrachloroethane, toluene, 1,1-dichloroethene, and 1,2-dichloroethane. Concentrations of these constituents in the repository are not expected to exceed the concentrations used in the accident analyses. Therefore, all nine of these constituents were included in the analyses for long-term PA.

H.5.2.3 Selection of Hazardous Metals

The accident analyses performed for SEIS-II included hazardous metals, specifically lead, mercury, cadmium, and beryllium, because these were the metals with the highest potential for health impacts when introduced into the environment. The same four metals were included in the analyses for long-term PA.

H.5.2.4 Solubility-Controlled Release Model Parameters

Solubility-controlled release models available in the NUTS code were used in the source-term release models for the Proposed Action and Action Alternative 1, 2, and 3 inventories for all undisturbed and disturbed cases. Data used in the analyses were selected from the probabilistic distributions of solubility of key radionuclides and hazardous chemicals, which are available in SNL model databases for PA calculations supporting the *Draft No-Migration Variance Petition* and the DCCA. Median and seventy-fifth percentile values of solubility for selected radionuclides are presented in Table H-7.

H.6 DATA AND PARAMETERS USED IN ANALYSIS

H.6.1 Model Geometry

A common model geometry provides a framework for simulation of the long-term performance of the repository, the shaft and shaft seal, the Salado Formation, and the hydrostratigraphic units above and below the Salado Formation. A two-dimensional repository grid geometry implemented with the BRAGFLO code for the *Draft No-Migration Variance Petition* (DOE 1995b) and the DCCA (DOE 1995a), shown in Figure H-4, was used to represent the three-dimensional geometry of the disposal system for analysis of undisturbed conditions. This grid represents a vertical north-south cross section through the disposal system and shows the distribution of grid blocks associated with important features of the disposal system and the major hydrostratigraphic units overlying the Salado Formation. Associations between grid blocks and material properties of major features and units are shown in Figure H-4 by pattern and number.

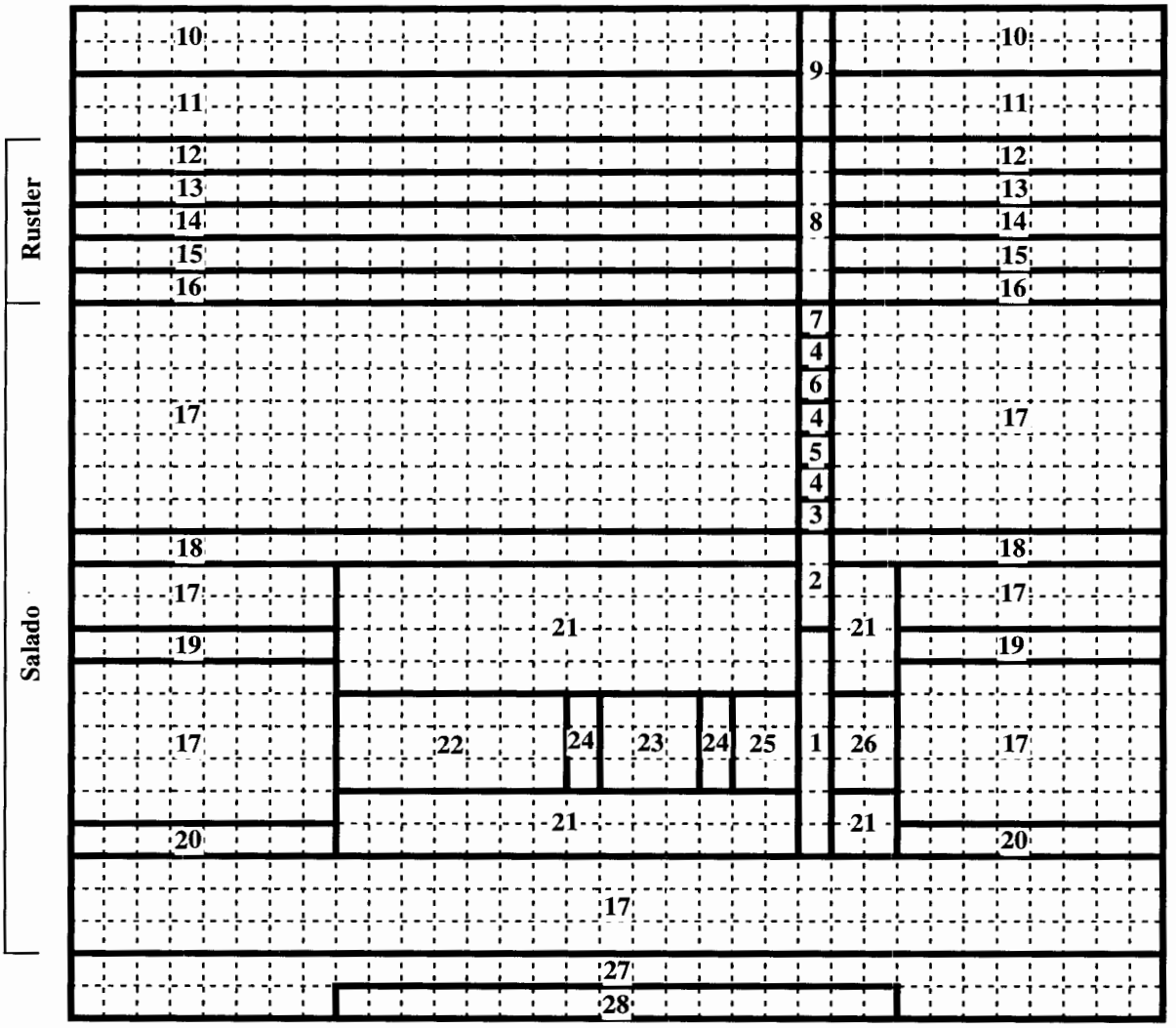
Table H-7
Log Solubility Values for Selected Radionuclides [a]

Constituent	Median Values	75th Percentile Values
Actinium	-4.26	-4.02
Americium	-5.55	-5.32
Beryllium	-6.0	-4.0
Bismuth	0	0
Cadmium	-6.0	-4.0
Cesium	0	0
Curium	-4.26	-4.02
Mercury	-6.0	-4.0
Neptunium	-4.26	-4.02
Protactinium	-4.26	-4.02
Lead	0	0
Polonium	0	0
Plutonium	-4.87	-4.63
Radium	0	0
Radon	0	0
Strontium	0	0
Thorium	-4.63	-4.39
Uranium	-4.90	-4.67
Yttrium	0	0

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the DCCA (DOE 1995a).

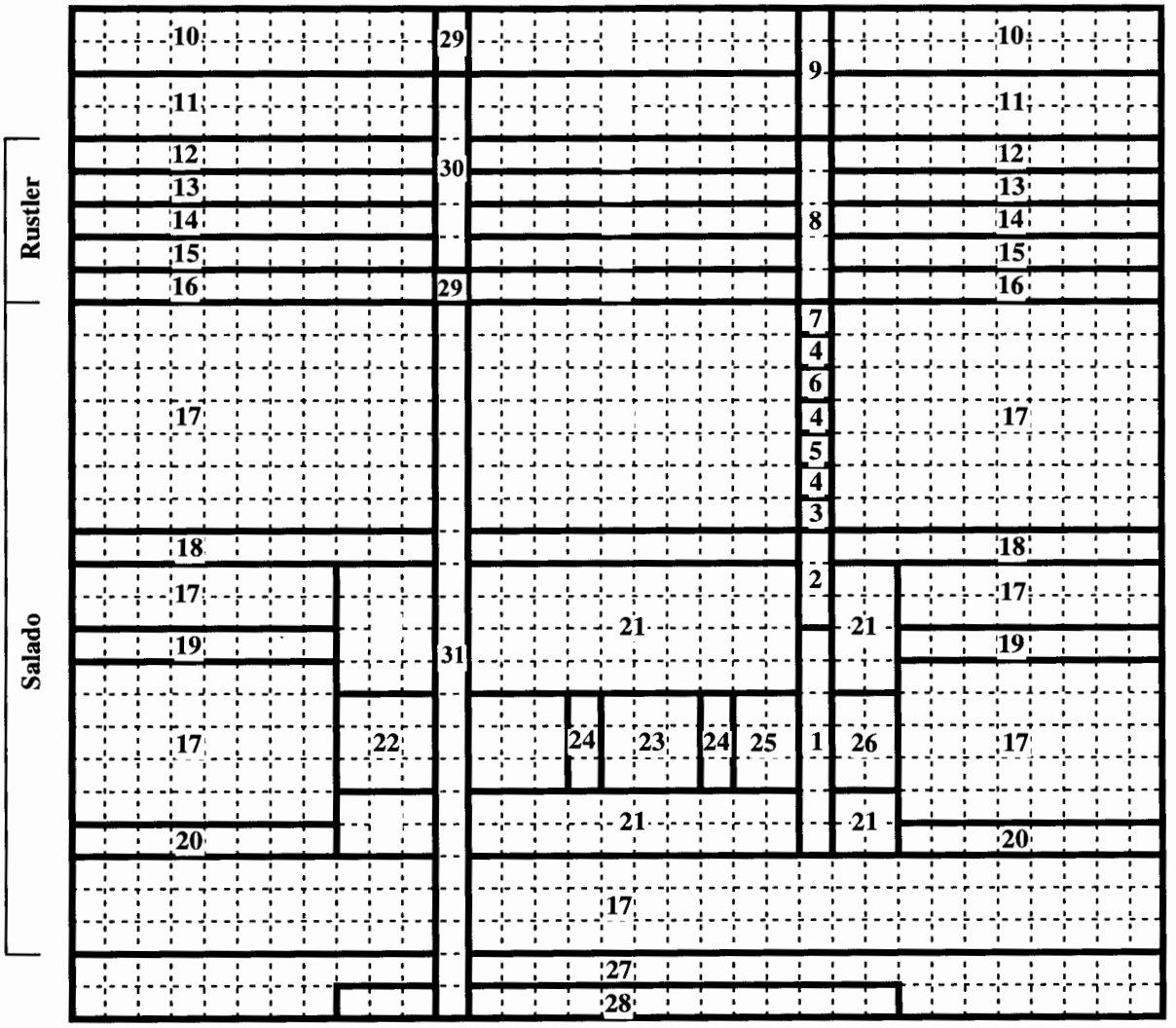
While the equidimensional grid system (Figure H-4) shows the relationship among material regions in the model and how connections are made within the finite-difference scheme of the BRAGFLO code, the grid greatly distorts the volumetric relationship between grid blocks. While the grid system measures about 1,000 meters (3,280 feet) in vertical thickness, the relatively thin waste panel area appears disproportionately thick. The modeled system extends approximately 23.3 kilometers (14.5 miles) to the north and south from the center of the grid system. The same BRAGFLO mesh, shown in Figure H-5, had a slightly different material property distribution to represent an intrusion borehole (material zones 29 to 31) and was used to simulate the disposal system for disturbed conditions.

The top-down (plan) view of the model shown in Figure H-6 illustrates the dimension of the grid system in the orthogonal (out-of-plane) direction to the grid depicted in Figures H-4 and H-5. This view shows the approach adopted to simulate radially convergent or divergent flow. Effects of flow in the third (out-of-plane) dimension are approximated with a two-dimensional element configuration that simulates radially convergent or divergent flow in two directions, centered on the repository, in intact rocks, and laterally away from the repository. The effects of the grid assumptions on fluid-flow processes in the Salado Formation are discussed in Section H.6.5 and in the *Draft No-Migration Variance Petition* (Appendix MASS of DOE 1995b).



1. Concrete Monolith
2. Lower Clay Component
3. Lower Salado Compacted Clay
4. Concrete
5. Crushed Salt (Salado Salt Column)
6. Upper Salado Compacted Clay
7. Asphalt
8. Rustler Clay Component
9. Earth Fill
10. Units Above the Dewey Lake
11. Dewey Lake Formation
12. Forty-Niner Member
13. Magenta Dolomite Member
14. Tamarisk Member
15. Culebra Dolomite Member
16. Unnamed Lower Member
17. Salado Halite
18. Marker Bed 138
19. Anhydrite Layer A & B
20. Marker Bed 139
21. Disturbed Rock Zone
22. Waste Panel
23. Rest of Repository
24. Panel Seals
25. Operation Region
26. Experimental Area
27. Castile Formation
28. Castile Brine Reservoir

Figure H-4
Vertical North-South Cross Section of the Model Grid Through the Disposal System for the Undisturbed Cases



1. Concrete Monolith
2. Lower Clay Component
3. Lower Salado Compacted Clay
4. Concrete
5. Crushed Salt (Salado Salt Column)
6. Upper Salado Compacted Clay
7. Asphalt
8. Rustler Clay Component
9. Earth Fill
10. Units Above the Dewey Lake
11. Dewey Lake Formation
12. Forty-Niner Member
13. Magenta Dolomite Member
14. Tamarisk Member
15. Culebra Dolomite Member
16. Unnamed Lower Member
17. Salado Halite
18. Marker Bed 138
19. Anhydrite Layer A & B
20. Marker Bed 139
21. Disturbed Rock Zone
22. Waste Panel
23. Rest of Repository
24. Panel Seals
25. Operation Region
26. Experimental Area
27. Castile Formation
28. Castile Brine Reservoir
29. Borehole Concrete Plug
30. Upper Unrestricted Borehole
31. Lower Unrestricted Borehole

Figure H-5
Vertical North-South Cross Section of the Model Grid Through the Disposal System for the Disturbed Cases

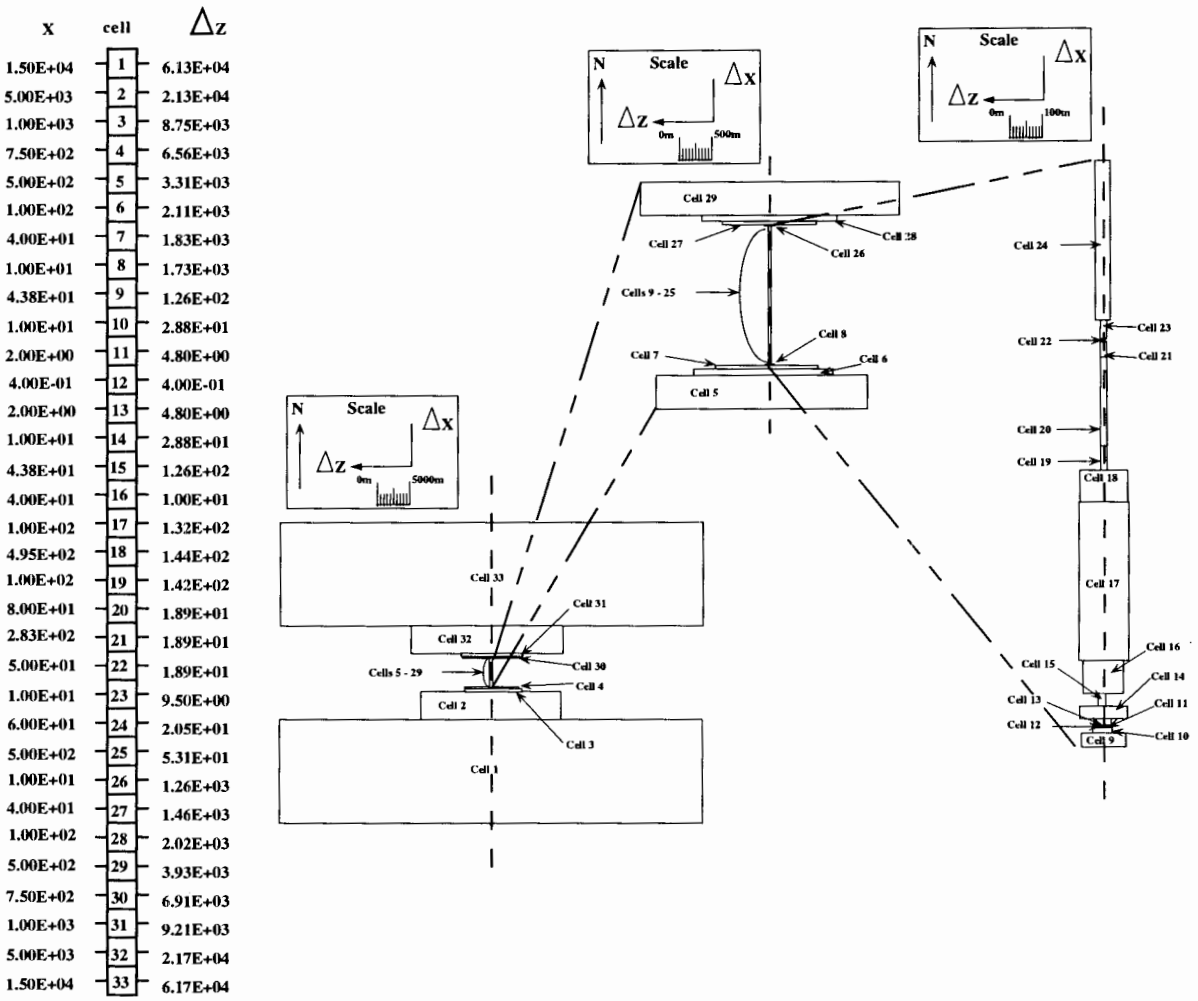


Figure H-6
Top-Down (Plan) View of the Model Through the Disposal System

To simulate long-term performance of Action Alternatives 1, 2, and 3, adjustments were made to the model geometry to reflect the changes in waste volumes defined for the action alternatives. Waste volumes are distributed between two sets of grid blocks, the panel and the rest of the repository grid spaces, as shown in Figure H-7. To accommodate the prescribed volumes, only the z dimension of grid spaces, representing the rest of the repository, were adjusted. A summary of these adjustments is provided in Table H-8. The x and y dimensions of these same grid spaces and the x, y, and z dimensions of the other grid spaces, representing the panel and all other elements of the disposal system, remained the same for all simulations.

The characteristics of the hydrostratigraphic units depicted in Figures H-4 and H-5 at elevations near the repository horizon are based on the observed differences in permeability between anhydrite-rich interbeds and halite-rich intervals. Although not depicted in Figures H-4 and H-5, a 1-degree dip to the south in the BRAGFLO computational mesh has been incorporated to approximate the variable southerly dip observed in the Salado Formation.

H.6.2 Boundary and Initial Conditions

Initial conditions for a number of parameters used in the BRAGFLO model, such as liquid pressure, liquid saturation, ferrous metal, and biodegradable content in the waste disposal region, are assigned at the start of the long-term performance simulations for the modeled regions. Initial conditions for the repository and the Salado Formation were selected in the *Draft No-Migration Variance Petition* (DOE 1995b) to be consistent with the following assumptions:

- No gradients for flow exist in the Salado Formation.
- Pore pressures in the Salado Formation are elevated above hydrostatic from the surface but below lithostatic.
- Permeability and porosity in the Salado Formation are low.
- Excavation and waste emplacement result in partial drainage of the DRZ and subsequent evaporation of drained brine into mine air, which is then removed by air exchanged to the surface.

No-flow boundary conditions are assigned along all of the exterior boundaries of the computational mesh, except at the far-field boundaries of the Culebra and Magenta Members and the top of the grid (i.e., the surface of the ground). The far-field boundaries of the Culebra and Magenta Members are maintained at pressures of 0.85 and 0.90 megapascals, respectively, corresponding to the initial pressure conditions used in the Culebra and Magenta Members. The ground-surface grid blocks are maintained at 1 atmosphere, 0.10 megapascals; liquid saturations in these blocks are held constant at 20 percent.

H.6.2.1 Initial Conditions in the Salado Formation and DRZ

A five-year initial simulation was performed prior to the long-term simulation of the repository. The purpose of the five-year simulation was to determine the initial near-repository, partially drained DRZ conditions. The initial liquid pressures in the Salado are based on a Marker Bed (MB) 139 pressure of 12.5 megapascals at the shaft and adjusted throughout the Salado to account

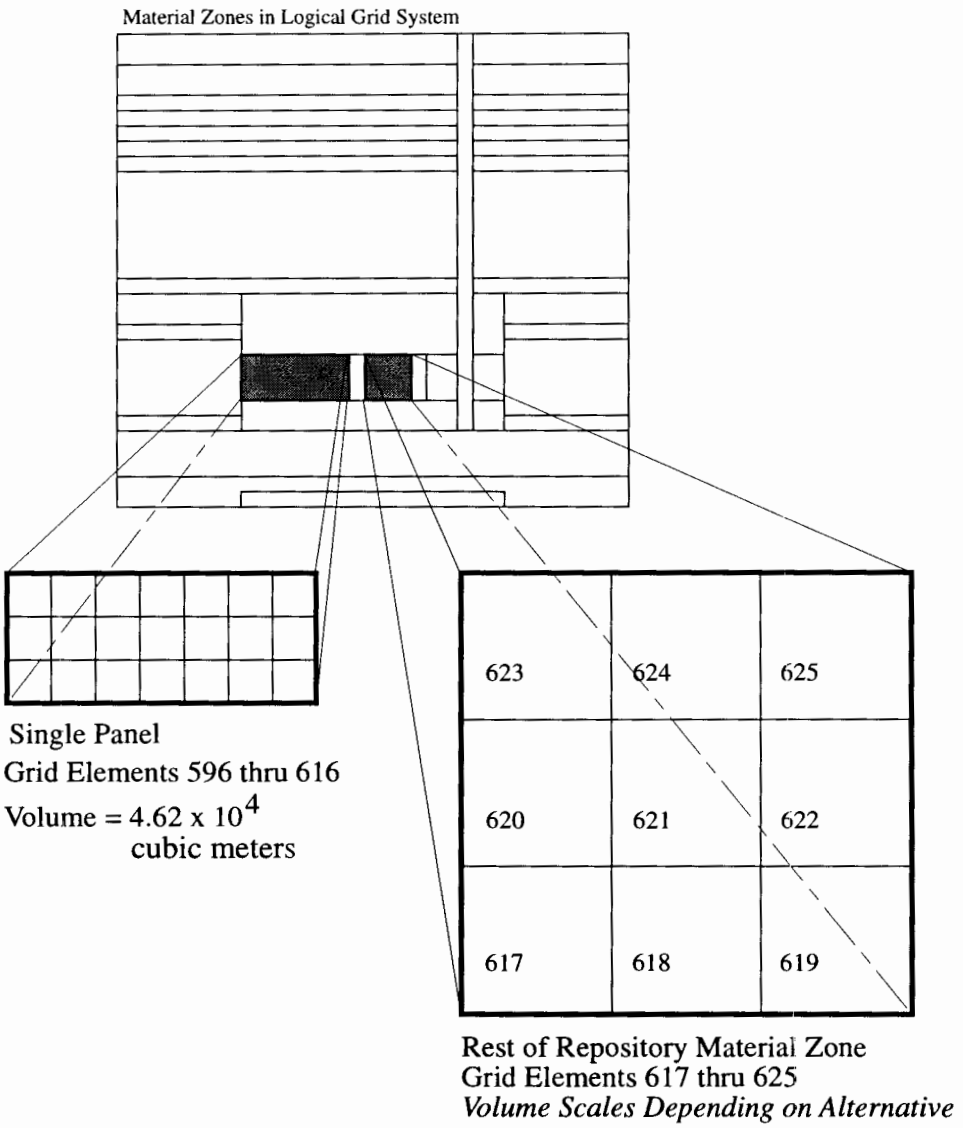


Figure H-7
Grid Spaces Representing the Rest of the Repository
Adjusted for Simulation of Action Alternatives 1, 2, and 3

Table H-8
Dimensional Lengths of Rest-of-Repository Material Zone Grid Elements for the Proposed Action; Action Alternatives 1, 2, 3; and Resulting Grid Element and Material Zone

Grid Element	x and y Element Length		Proposed Action		Action Alternative 1		Action Alternative 2		Action Alternative 3	
Index	x Depth (meters)	y Depth (meters)	z Depth (meters)	Volume (cubic meters)	z Depth (meters)	Volume (cubic meters)	z Depth (meters)	Volume (cubic meters)	z Depth (meters)	Volume (cubic meters)
617	100	1.3208	132.3	1.7E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
618	495	1.3208	143.5	9.4E+4	1060	6.9E+5	1171	7.7E+5	1108	7.2E+5
619	100	1.3208	141.6	1.9E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
620	100	1.3208	132.3	1.7E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
621	495	1.3208	143.5	9.4E+4	1060	6.9E+5	1171	7.7E+5	1108	7.2E+5
622	100	1.3208	141.6	1.9E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
623	100	1.3208	132.3	1.7E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
624	495	1.3208	143.5	9.4E+4	1060	6.9E+5	1171	7.7E+5	1108	7.2E+5
625	100	1.3208	141.6	1.9E+4	1060	1.4E+5	1171	1.5E+5	1108	1.5E+5
Rest of Repository Volume (cubic meters)				3.9E+5	- - -	2.9E+6	- - -	3.2E+6	- - -	3.1E+6
Separately Modeled Panel Volume (cubic meters)				4.6E+4	- - -	4.6E+4	- - -	4.6E+4	- - -	4.6E+4
Total Repository Volume (cubic meters)				4.4E+5	- - -	3.0E+6	- - -	6.5E+6	- - -	6.1E+6

for a 1-degree dip, assuming hydrostatic equilibrium. Permeability in the DRZ is 1 x 10^{-15} square meter for all time. The porosity of the DRZ is assumed as the value of impure halite, resulting in reduced storage volume. Porosity in lithologic units is initially 100 percent liquid-saturated during the initial simulation.

H.6.2.2 Initial Conditions in the Waste Disposal Region

In this analysis, the individual panels were assumed to remain open for 5 years to allow for waste emplacement. An initial period of 5 years is used to allow depressurization around the excavated regions to atmospheric pressure. After the initial 5-year period, the waste is placed at a liquid saturation of 0.0006 and a pressure of 1 atmosphere. The remaining excavations outside the waste disposal area are assigned a gas saturation of 100 percent and an initial pressure of 1 atmosphere. Corrosion and/or biodegradation reactions that produce gas are modeled to begin at time zero, T=0 years. For the purpose of this analysis, waste emplacement is assumed to occur instantaneously throughout the repository. The concentrations of ferrous metals and biodegradables in the waste regions are assigned initial parameter values of 158 and 92.5 kilograms per cubic meter (10 and 6 pounds per cubic foot), respectively.

H.6.2.3 Initial Conditions in the Shaft

After the initial 5-year period, shaft materials are emplaced. The initial pressure in the shaft is 1 atmosphere, and the initial liquid saturation of all shaft materials is 80 percent. The exception is the asphalt region, which is set at 0 percent.

H.6.3 Repository and Panel Parameters

The repository is represented by regions 22 to 26 in Figures H-4 and H-5. These regions include an isolated waste disposal panel (22), panel closures (24), panels and access drifts in the rest of the waste disposal region (23), operations region (25), and an experimental region at the north end of the repository (26). The four shafts connecting the repository to the surface are represented by a single shaft in regions 1 through 9 in Figures H-4 and H-5. The lower shaft region (1) intersects the repository between the operations and experimental regions.

As mentioned in the *Draft No-Migration Variance Petition* (DOE 1995b), the geometry depicted in the BRAGFLO model is a simplification of reality. The model geometry attempts to preserve the true excavated volume. Lateral dimensions have been defined to preserve the true excavated volume and retain important cross-sectional areas and distances between defined regions, as discussed below. These simplifications are conservative, with respect to fluid contact with waste, and are critical factors in determining the quantity of regulated contaminants dissolved in the aqueous phase. The simplifications are also conservative because (1) all pillars have been removed from panels, resulting in homogeneous waste regions through which fluid can flow directly; (2) panel closures are included to retain the effects of their dimensions on fluid flow and are modeled with a higher permeability than they are expected to have; and (3) panels in the rest of the repository have neither pillars nor closures, resulting in a very large region of homogeneous waste that is assigned transmissive properties.

The panel closure has a cross-sectional area for fluid flow equal to the cross-sectional area of the drifts between panels. The panel closure between the rest of the repository and the operations region has a cross-sectional area for fluid flow equal to the cross-sectional area of the drifts between the north end of the waste disposal region and the operations region. Because there are

two sets of closures between the waste disposal region and the shafts in the operations region, the panel closures between the rest of the repository and the operations region have a length equal to two sets of panel closures.

Median and 75th percentile performance values used for repository and panel closure parameters in this analysis are summarized in Table H-9. The values used for the gas-generation model in this analysis are presented in Table H-10. The reader is referred to the *Draft No-Migration Variance Petition* (Chapter 8 of DOE 1995b) for the relationship of these parameters to model simulation of salt creep, brine inflow, and gas generation in the repository system.

H.6.4 Shaft and Seal Parameters

The four shafts connecting the repository to the surface are represented with a single shaft in Figures H-4 and H-5. This single shaft has a cross section and volume equal to the four real shafts it represents, and it is separated from the waste disposal region in the model by the true north-south distance from the waste to the nearest shaft (the Waste Shaft). On closure of the repository, the shafts will be sealed, as described in the *Draft No-Migration Variance Petition* (Section 3.3.2 of DOE 1995b).

Table H-9
Repository and Panel Seal Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Repository		
Permeability (square meter)	1.7E-13	1.7E-13
Effective Porosity (percent)	85	85
Threshold Pressure P_t (pascals)[b]	0	0
Residual Brine Satuation S_{br} (unitless)[c]	0.3	0.1
Residual Gas Saturation S_{gr} (unitless)[c]	0.08	0.04
Pore Shape Distribution Parameter (unitless)[c]	2.9	2.2
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	0	0
Panel Seals		
Permeability (square meter) - Panel Seals	1.0E-15	1.0E-15
Effective Porosity (percent) - Panel Seals	7.5	7.5
Threshold Pressure P_t (pascals)[b] - Panel Seals	8.7E+4	8.7E+4
Residual Brine Satuation S_{br} (unitless)[c]	0.2	0.2
Residual Gas Saturation S_{gr} (unitless)[c]	0.2	0.2
Pore Shape Distribution Parameter (unitless)[c]	0.9	0.9
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	2.6E-9	2.6E-9

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Table H-10
Average Stoichiometry Gas-Generation Model Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Rate of Gas Generation by Corrosion in Brine-Inundated Conditions (mol H_2/square meter Fe/second)	1.3E-8	1.9E-8
Rate of Gas Generation by Corrosion in Humid Conditions (multiplicative factor of inundated rate)	0	0
Rate of Gas Generation by Biodegradation in Inundated Conditions (mol/kilogram second)	3.2E-7	3.2E-7
Rate of Gas Generation by Biodegradation in Humid Conditions (multiplicative factor of inundated rate)	0.1	0.1
Anoxic Corrosion Stoichiometric Factor (unitless)	0.5	0.5
Stoichiometric Factor for Microbial Gas Generation	1.1	1.1
Fraction of Plastics and Rubbers that are Biodegradable (unitless)	1	1
Average Density of Iron-Based Materials in CH-TRU Waste (kilogram/cubic meter)	140	140
Average Density of Iron-Based Materials in RH-TRU Waste (kilogram/cubic meter)	130	130
Average Density of Plastics in CH-TRU Waste (kilogram/cubic meter)	51	51
Average Density of Plastics in RH-TRU Waste (kilogram/cubic meter)	19	19
Average Density of Rubber in CH-TRU Waste (kilogram/cubic meter)	16	16
Average Density of Rubber in RH-TRU Waste (kilogram/cubic meter)	3.1	3.1
Bulk Density of Iron Containers, CH-TRU Waste (kilogram/cubic meter)	280	280
Bulk Density of Iron Containers, RH-TRU Waste (kilogram/cubic meter)	2,650	2,650
Bulk Density of Plastic Liners, CH-TRU Waste (kilogram/cubic meter)	32	32
BIR Total Volume of RH-TRU Waste (cubic meter)	7,080	7,080
BIR Total Volume of CH-TRU Waste (cubic meter)	168,500	168,500
Index for Computing Wicking (unitless)	0.5	0.5

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).

Median and 75th percentile values for shaft component materials and properties used in the simulation are given in Table H-11. From top to bottom, the system is represented in the simulation by the following materials:

- An earthen fill region above the Rustler Formation
- A clay region in the Rustler Formation (designated Rustler clay)
- Three concrete sections (upper, middle, lower) within the Salado, consolidated for modeling purposes into a single concrete region with the same total thickness
- A thick section of compacted crushed salt within the Salado
- An upper compacted clay region within the Salado (designated upper Salado compacted clay)

Table H-11
Shaft Materials Parameter Values [a]

Parameter (units) - Clay Shaft Material	Median Values	75th Percentile Values
Permeability (square meter), Rustler Clay (0 to 10,000 year)	5.0E-19	5.0E-19
Permeability (square meter), Upper Salado Compacted Clay (0 to 10 year)	5.0E-19	5.0E-19
Permeability (square meter), Upper Salado Compacted Clay (10 to 25 year)	5.0E-19	5.0E-19
Permeability (square meter), Upper Salado Compacted Clay (25 to 50 year)	5.0E-19	5.0E-19
Permeability (square meter), Upper Salado Compacted Clay (50 to 100 year)	5.0E-19	5.0E-19
Permeability (square meter), Upper Salado Compacted Clay (50 to 100 year)	5.0E-19	5.0E-19
Permeability (square meter), Upper Salado Compacted Clay (After 100 year)	5.0E-19	5.0E-19
Permeability (square meter), Lower Salado Compacted Clay (0 - 10 year)	5.0E-19	5.0E-19
Permeability (square meter), Lower Salado Compacted Clay (10 - 25 year)	5.0E-19	5.0E-19
Permeability (square meter), Lower Salado Compacted Clay (After 25 year)	5.0E-19	5.0E-19
Permeability (square meter), Bottom Clay (0 to 10,000 year)	5.0E-19	5.0E-19
Thickness (meter), Rustler Clay	94	94
Thickness (meter), Upper Salado Compacted Clay	1.1E+3	1.1E+3
Thickness (meter), Lower Salado Compacted Clay	24	24
Thickness (meter), Bottom Clay	4.6	4.6
Effective Porosity (percent), Rustler Clay	24	24
Effective Porosity (percent) Upper, Lower, and Bottom Clays	24	24
Residual Brine Saturation S_{br} (unitless)[b]	0.2	0.1
Residual Gas Saturation S_{gr} (unitless)[b]	0.2	0.1
Pore Shape Distribution Parameter (unitless)[b]	0.9	0.5
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	2.0E-9	2.0E-9
Permeability (square meter), Salt (0 to 10 year)	1.7E-15	1.7E-15
Permeability (square meter), Salt (10 to 25 year)	1.7E-15	1.7E-15
Permeability (square meter), Salt (25 to 50 year)	1.6E-15	1.6E-15
Permeability (square meter), Salt (50 to 100 year)	1.5E-18	1.5E-18
Permeability (square meter), Salt (100 to 200 year)	6.1E-20	6.1E-20
Permeability (square meter), Salt (After 200 year)	5.3E-21	5.3E-21
Permeability (square meter), Concrete (0 to 100 year)	1.8E-19	1.8E-19
Permeability (square meter), Concrete (After 100 year)	1.0E-14	1.0E-14
Thickness (meter), Salt	1.7E+3	1.7E+3
Thickness (meter), Upper, Middle, and Lower Concrete	45	45
Thickness (meter), Shaft Station Monolith Concrete	14	14
Effective Porosity (percent), Salt	5	5
Effective Porosity (percent) Concrete	5	5

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Table H-11
Shaft Materials Parameter Values-Continued [a]

Parameter (units) - Clay Shaft Material	Median Values	75th Percentile Values
Threshold Pressure P_t (pascals)[c], Salt (0 to 10 year)	7.1E+4	7.1E+4
Threshold Pressure P_t (pascals)[c], Salt (10 to 25 year)	7.3E+4	7.3E+4
Threshold Pressure P_t (pascals)[c], Salt (25 to 50 year)	7.3E+4	7.3E+4
Threshold Pressure P_t (pascals)[c], Salt (50 to 100 year)	8.3E+5	8.3E+5
Threshold Pressure P_t (pascals)[c], Salt (100 to 200 year)	2.5E+6	2.5E+6
Threshold Pressure P_t (pascals)[c], Salt (After 200 year)	5.8E+6	5.8E+6
Threshold Pressure P_t (pascals)[c], Concrete (0 to 100 year)	1.7E+6	1.7E+6
Threshold Pressure P_t (pascals)[c], Concrete (After 100 year)	3.9E+4	3.9E+4
Residual Brine Saturation S_{br} (unitless)[b]	0.2	0.2
Residual Gas Saturation S_{gr} (unitless)[b]	0.2	0.2
Pore Shape Distribution Parameter (unitless)[b]	0.9	0.9
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	1.6E-9	1.6E-9
Permeability (square meter), Backfill and Experimental Area	1.0E-11	1.0E-11
Permeability (square meter), Asphalt	1.0E-20	3.9E-20
Thickness (meter), Asphalt	37	37
Effective Porosity (percent), Experimental Area and Backfill	18	18
Effective Porosity (percent) Asphalt	1	1
Threshold Pressure P_t (pascals)[c]	0	0
Residual Brine Saturation S_{br} (unitless)[b]	0	0
Residual Gas Saturation S_{gr} (unitless)[b]	0	0
Pore Shape Distribution Parameter (unitless)[b]	0.7	0.7
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	3.0E-8	3.0E-8
Permeability (square meter)	1.0E-14	3.8E-14
Thickness (meter)	1.7E+3	1.7E+3
Effective Porosity (percent)	32	32
Threshold Pressure P_t (pascals)[c]	3.9E+4	2.5E+4
Residual Brine Saturation S_{br} (unitless)[b]	0.2	0.1
Residual Gas Saturation S_{gr} (unitless)[b]	0.2	0.1
Pore Shape Distribution Parameter (unitless)[b]	0.9	0.5
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	3.1E-8	3.1E-8

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).
[c] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.

- A lower compacted clay region within the Salado (designated lower Salado compacted clay)
- A basal clay component below MB 138 (designated bottom clay)
- A lower concrete section at the repository horizon (designated shaft station concrete monolith)
- An asphalt region at the top of the Salado Formation

Additional documentation of the shaft material parameters and their use in the BRAGFLO analysis are described in the *Draft No-Migration Variance Petition* (Chapter 8 and Appendix PAR in DOE 1995b).

H.6.5 Salado Formation

The Salado Formation is a porous medium composed of several rock types arranged in layers, through which flow occurs according to Darcy's law (see description in the *Draft No-Migration Variance Petition* [DOE 1995b]). Two rock types, impure halite and anhydrite, are used to represent the intact Salado. The DRZ near the repository has increased permeability compared to intact rock and offers little resistance to flow between anhydrite interbeds and the repository. Conceptually, this simulation assumes constant properties for Salado rock, based on observations of compositional and structural regularity in layers exposed by the repository. The inference is that there is little variation in large-scale averages of rock or flow properties across the disposal system.

H.6.5.1 Impure Halite

In this analysis, a single, porous medium with spatially constant rock and hydrologic properties (see region 17 in Figures H-4 and H-5) is used to represent intact, halite-rich layers in the Salado. Minor interbeds are contained within those layers that are not explicitly represented. Table H-12 shows median and 75th percentile parameter values used in modeling the Salado impure halite. Additional information on the use of these parameter values in BRAGFLO simulations is contained in the *Draft No-Migration Variance Petition* (Chapter 8 and Appendix PAR in DOE 1995b).

H.6.5.2 Anhydrite Interbeds

Three distinct anhydrite interbeds are modeled in this BRAGFLO simulation, representing MB 138 (region 18), anhydrite layers a and b (region 19), and MB 139 (region 20), all shown in Figures H-4 and H-5. The three interbeds have the same set of model parameters and, initially, the parameters are spatially constant. Porosity and permeability can vary spatially during a simulation, depending on interbed fracturing. The interbeds differ only in position and thickness. The three interbeds are included because they exist in the disturbed region around the repository, within which fluid is expected to flow with relative ease compared to the surrounding formation. MB 139 and anhydrite layers a and b are present within the DRZ that forms around excavations; MB 138 may be above the DRZ but is below the long-term seal components that will be constructed in the shafts. MB 138 is included because of its uncertainty in the long-term isolation from the repository. Median and 75th percentile values used for parameters associated with the interbeds are shown in Table H-13.

Table H-12
Salado Formation Halite Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	3.2E-23	1.8E-22
Effective Porosity (percent)	1.0	0.6
Specific Storage (1/meter)	1.0E-6	1.0E-6
Threshold Pressure P_t (pascals)[b]	3.4E+7	1.9E+7
Residual Brine Saturation (unitless)[c]	0.3	0.2
Residual Gas Saturation (unitless)[c]	0.2	0.1
Pore Shape Distribution Parameter (unitless)[c]	0.7	0.5
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	8.1E-9	8.1E-9

[a] Median and 75th percentile values used were based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Table H-13
Salado Formation Anhydrite Interbeds A and B and Marker Beds 138 and 139 Parameter Values [a]

Parameter (units)	Median Values	75th Percentile values
Permeability (square meter)	1.3E-19	8.2E-19
Effective Porosity (percent)	1.1	0.9
Threshold Pressure P_t (pascals)[b]	9.7E+5	5.1E+5
Residual Brine Saturation S_{br} (unitless)[c]	0.088	0.05
Residual Gas Saturation S_{gr} (unitless)[c]	0.08	0.038
Pore Shape Distribution Parameter (unitless)[c]	0.6	0.6
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	8.3E-11	1.6E-10

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Table H-14 lists median and 75th percentile values of parameters used in the model for interbed dilation and fracture. Documentation on the selection and use of these parameters in BRAGFLO simulations are found in the *Draft No-Migration Variance Petition* (Chapter 8 and Appendix PAR in DOE 1995b).

Table H-14
Salado Formation Anhydrite Interbeds A and B and Marker Beds 138 and 139 Fracture Parameter Values [a]

Parameter (units)	Values
Fracture Initiation Pressure (pascals)	1.4E+6
Increment to Give Full Fracture Porosity (percent)	1.0
Maximum Permeability (square meter)	1.0E-9
Increment of Lithostatic Pressure to Obtain Maximum Fracture Pressure (pascals)	2.5E+6
Brine Far-Field Pore Pressure (pascals)	1.3E+7

[a] Values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).

H.6.5.3 Disturbed Rock Zone

Near the repository at the Salado Formation, the permeability and porosity of the DRZ salt are expected to increase over that of intact salt. The increases in the permeability and porosity of salt in interbeds are not expected to be completely reversible with creep closure of the disposal rooms. The increase in DRZ permeability affects the ability of fluid to flow from interbeds to the waste disposal region.

The increase in DRZ porosity provides a volume in which some fluid could be retained so that it does not contact waste. DRZ pore volume can also slow radionuclide and hazardous constituent migration.

In this analysis, the permeability of a region around the repository is increased relative to intact Salado rock for the duration of the simulation and the threshold pressure is set to zero. The porosity of this region is left equal to the porosity of Salado halite to prevent reduced fluid retention in the DRZ. The DRZ extends above and below the repository from the base of MB 138 to MB 139. Defining the DRZ in this manner creates a permanent, highly permeable region that does not impede flow between the repository and interbeds. Median and 75th percentile values of the parameters used in the representation of the DRZ are summarized in Table H-15.

H.6.5.4 Units Above the Salado Formation

The BRAGFLO simulations used in this analysis consider the Unnamed Lower, Culebra, Tamarisk, Magenta, and Forty-Niner Members of the Rustler Formation, the Dewey Lake Formation, the Gatuna Formation, and the Santa Rosa Formation. For modeling purposes, the parameters of the Gatuna and Santa Rosa Formations were combined and reported with the Santa Rosa Formation parameters. BRAGFLO separates and calculates flow in these units to establish the pressure gradient in the disposal system. The other three Rustler Formation members are modeled as effectively impermeable. These units are represented in the BRAGFLO element mesh by regions 10 through 16 (shown in Figures H-4 and H-5).

For this simulation, the water table is located approximately 59 meters (194 feet) below the ground surface at an elevation of 980 meters (3,215 feet) within the Dewey Lake Formation. For regions above the water table, the initial liquid saturation of 20 percent (the residual liquid saturation of the

Table H-15
Disturbed Rock Zone Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	1.0E-17	1.0E-17
Effective Porosity (percent)	1.3	1.3
Threshold Pressure P_t (pascals)[b]	0	0
Residual Brine Saturation S_{br} (unitless)[c]	0	0
Residual Gas Saturation S_{gr} (unitless)[c]	0	0
Pore Shape Distribution Parameter (unitless)[c]	0.7	0.7
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	7.4E-10	7.4E-10

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Dewey Lake and Santa Rosa Formations) is used. For regions above the water table, the initial liquid pressure is assumed to be 1 atmosphere. For the portion of the Dewey Lake Formation below the water table and the Rustler Formation regions (excluding the Culebra and Magenta Members, which are specified at 0.85 and 0.90 megapascal, respectively), a hydrostatic gradient is assumed for specifying the initial pressure conditions. For the time period -5 to 0 years, all regions above the Salado are treated as impermeable. Conceptually, this corresponds to the emplacement of liners in the shafts. Median and 75th percentile parameter values for these units are presented in Tables H-16, H-17, H-18, H-19, and H-20. Documentation of the selection and use of these parameters is described in more detail in the *Draft No Migration Variance Petition* (Chapter 8 and Appendix PAR in DOE 1995b).

Table H-16
Culebra Member of the Rustler Formation Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	2.1E-14	2.1E-14
Effective Porosity (percent)	15.1	15.1
Threshold Pressure P_t (pascals)[b]	0	0
Residual Brine Saturation S_{br} (unitless)[c]	0.08	0.08
Residual Gas Saturation S_{gr} (unitless)[c]	0.08	0.08
Pore Shape Distribution Parameter (unitless)[c]	0.6	0.6
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	1.0E-10	1.0E-10

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Table H-17
Magenta Member of the Rustler Formation Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	6.3E-16	6.3E-16
Effective Porosity (percent)	13.8	19.3
Threshold Pressure P_t (pascals)[b]	5.1E+4	5.1E+4
Residual Brine Saturation S_{br} (unitless)[c]	0.08	19.3
Residual Gas Saturation S_{gr} (unitless)[c]	0.08	0.08
Pore Shape Distribution Parameter (unitless)[c]	0.6	0.6
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	2.6E-10	2.6E-10

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Table H-18
Forty-Niner, Tamarisk, and Unnamed Lower Members of the Rustler Formation Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	1.0E-35	1.0E-35
Effective Porosity (percent) - Forty Niner Member	8.2	1.3
Effective Porosity (percent) - Tamarisk Member	6.4	4.3
Effective Porosity (percent) - Unnamed Lower Member	18.1	9.6
Threshold Pressure P_t (pascals)[b]	0	0
Residual Brine Saturation S_{br} (unitless)[c]	0.2	0.2
Residual Gas Saturation S_{gr} (unitless)[c]	0.2	0.2
Pore Shape Distribution Parameter (unitless)[c]	0.7	0.7
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	0	0

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Table H-19
Dewey Lake Formation Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	5.0E-17	5.0E-17
Effective Porosity (percent)	14.3	9.1
Threshold Pressure P_t (pascal)[b]	1.2E+5	1.2E+5
Residual Brine Saturation S_{br} (unitless)[c]	0.08	0.08
Residual Gas Saturation S_{gr} (unitless)[c]	0.08	0.08
Pore Shape Distribution Parameter (unitless)[c]	0.6	0.6
Maximum Capillary Pressure (pascal)	1.0E+8	1.0E+8
Pore Compressibility (1/pascal)	1.0E-8	1.0E-8
Thickness (meter)	1.5E+3	1.5E+3
Initial Pressure (pascal)	hydrostatic; water table at 980 meters, 43.3 meters below top of formation	
Initial Pressure (atm) 20 percent Liquid Saturation, Above Water Table	1.0	1.0

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Table H-20
Santa Rosa Formation Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	1.0E-10	1.0E-10
Effective Porosity (percent)	17.5	17.5
Threshold Pressure P_t (pascals)[b]	0	0
Residual Brine Saturation S_{br} (unitless)[c]	0.08	0.08
Residual Gas Saturation S_{gr} (unitless)[c]	0.08	0.08
Pore Shape Distribution Parameter (unitless)[c]	0.06	0.06
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	1.0E-8	1.0E-8
Thickness (meter)	15.8	15.8
Initial Pressure (atm) 20 percent Liquid Saturation, Above Water Table	1.0	1.0

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

H.6.6 The Castile Formation

The BRAGFLO simulations used in both the undisturbed and disturbed analyses considered the Castile Formation to incorporate the effects of brine pocket pressure below the Salado Formation. The Castile Formation is represented in the BRAGFLO element mesh by region 27 (shown in Figures H-4 and H-5).

The brine pocket pressure represented in the BRAGFLO element mesh by region 28 (see Figures H-4 and H-5) was represented in median parameter cases by an initial pressure of 12.5 megapascals and in 75th percentile parameter cases by 14.0 megapascals. For undisturbed cases, this initial pressure has little impact on the predicted pressure field. For the disturbed cases, however, this unit is penetrated by an intrusion borehole, allowing its hydraulic impact to be transmitted to other units within the modeled domain, most notably the repository and the Culebra Dolomite Member.

Median and 75th percentile values of important parameters for the Castile Formation and Brine Reservoir are presented in Tables H-21 and H-22. Documentation of the selection and use of these parameters is described in more detail in the DCCA (Chapter 6 in DOE 1995a).

H.6.7 Intrusion Borehole

For the disturbed cases, BRAGFLO simulations considered an intrusion borehole that penetrates the entire sequence of units in the modeled domain. The borehole is represented in the BRAGFLO element mesh by region 29-31 (see Figure H-5). The intrusion borehole was assumed to be an exploratory borehole that penetrates the WIPP repository and extends through a pressurized brine reservoir in the Castile Formation, creating a potential pathway between the brine reservoirs and the repository. This pathway could inundate the repository and flush water material from the repository to overlying water-bearing units in the Rustler Formation and other near-surface units.

Table H-21
Castile Formation Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	1.0E-35	1.0E-35
Effective Porosity (percent)	0.5	0.5
Threshold Pressure P_t (pascals)[b]	0	0
Residual Brine Saturation S_{br} (unitless)[c]	0	0
Residual Gas Saturation S_{gr} (unitless)[c]	0	0
Pore Shape Distribution Parameter (unitless)[c]	0.7	0.7
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	0	0

[a] Median and 75th percentile values were used based on the data and parameter distributions contained in the *Draft No-Migration Variance Petition* (Appendix PAR in DOE 1995b).
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Table H-22
Brine Reservoir Parameter Values [a]

Parameter (units)	Median Values	75th Percentile Values
Permeability (square meter)	1.6E-12	6.1E-12
Effective Porosity (percent)	0.9	1.4
Threshold Pressure P_t (pascals)[b]	6.8E+3	4.2E+3
Residual Brine Saturation S_{br} (unitless)[c]	0.2	0.2
Residual Gas Saturation S_{gr} (unitless)[c]	0.2	0.2
Pore Shape Distribution Parameter (unitless)[c]	0.7	0.7
Maximum Capillary Pressure (pascals)	1.0E+8	1.0E+8
Pore Compressibility (pascal^{-1})	1.0E-10	3.9E-10
Initial Brine Pressure (pascals)	1.3E+7	1.4E+7
Volume (cubic meter)	4.0E+6	4.0E+6

[a] Median and 75th percentile values were used based on data and parameter distributions contained in DCCA (DOE 1995a).
[b] Threshold pressure (P_t) was determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

Under this scenario, it was assumed that the borehole would be drilled and plugged at abandonment using standard regulatory requirements and practices. The parameters used to represent this scenario were based on intrusion borehole permeability studies described in Thompson et al. (1996). These studies evaluated two parameters: the long-term estimates of permeabilities in exploratory borehole materials, and the dimensions from the review of current regulatory requirements and drilling and borehole plugging practices. Using models and data for steel corrosion and concrete alteration, estimates of long-term changes in borehole permeabilities for three different borehole plugging configurations were made. These three configurations were:

- Borehole with a continuous plug - For this scenario, a single continuous plug is emplaced through the entire sequence of evaporites in the Castile and Salado Formations. In current practices, this approach to plugging a borehole represents the maximum standards for plugging in the Delaware Basin.

- Borehole with two plugs - For this scenario, a cement plug is placed in the Bell Canyon below the depth of the Castile Formation brine pockets, and a second plug is placed in the Rustler Formation between the Culebra Dolomite and the repository. This configuration represents the minimum standards for plugging in the Delaware Basin.

- Borehole with multiple plugs - For this configuration, plugs are emplaced as in the two-plug scenario. An additional plug is emplaced in the Salado Formation between the repository and the Castile formation brine pockets. This multiplugging scheme represents a more typical approach to borehole plugging in the Delaware Basin.

Over the 10,000-year period of interest, properties of boreholes and plugging materials will change and degrade by a variety of degradation mechanisms including (1) iron corrosion of well steel casing, (2) concrete degradation, and (3) salt creep. According to Thompson et al. (1996), borehole plugs would initially be expected to have a permeability of 5×10^{-17} square meters. In the

continuous plug scenario, the borehole permeability is expected to remain largely undiminished. For the other plugging configurations, the properties of various sections of the borehole would be expected to change with time. Casing in upper parts of the borehole above the Rustler Formation are estimated to degrade completely within a 200-year period. This degradation would cause the plug in the Rustler to fail over time, and the corroded casing and plug would likely spill into the borehole, filling it with material that would likely have a permeability similar to silty sand (1×10^{-11} to 1×10^{-14} square meters). Over time, salt creep would compress this material into the borehole, creating a permeability about one order of magnitude less. For deeper plugs in the borehole, the casing would not corrode as extensively, and the plugs at that depth would not fail for an estimated time of 500 years.

For the purpose of this analysis, the two-plug configuration was selected for the disturbed cases since it is the minimal plugging practice in the Delaware Basin. Parameter values used to represent the intrusion borehole for all disturbed cases are presented in Table H-23.

Table H-23
Exploratory Borehole Parameter Values Used After Intrusion

Parameter (units)	Values[a]
Borehole Plug Permeability (square meter) (0 to 200 years after intrusion)	5.0E-17
Borehole Permeability (square meter) (0 to 200 years after intrusion)	1.0E-9
Borehole Permeability (square meter) (after 200 years after intrusion)	3.2E-13
Permeability (square meter), Borehole Permeability Below WIPP (square meter) (After 1200 years after intrusion)	3.2E-14
Effective Porosity (percent)	0.3
Threshold Pressure P_t (pascals)[b]	0
Residual Brine Saturation S_{br} (unitless)[c]	0
Residual Gas Saturation S_{gr} (unitless)[c]	0
Pore Shape Distribution Parameter (unitless)[c], Borehole Plugs (0 to 100 years after intrusion), Borehole (After 200 years after intrusion), and Borehole below WIPP (After 1200 years after intrusion)	0.7
Pore Shape Distribution Parameter (unitless)[c], Borehole (0 to 200 years after intrusion)	0.9
Maximum Capillary Pressure (pascals)	1.0E+8
Pore Compressibility ($pascal^{-1}$)	0

[a] Values used were based on data contained in the DCCA (DOE 1995a) and Thompson et al (1996).
[b] Threshold pressure (P_t) determined from the relationship: $P_t = PCT_A\ k^{(PCT_EXP)}$, where PCT_A and PCT_EXP are constants and k is the permeability.
[c] Two-phase flow: Brooks-Corey model used (Appendix BRAGFLO in DOE 1995a).

H.7 ANALYSIS OF LONG-TERM PERFORMANCE ASSESSMENT

Additional detail regarding the modeling results for the long-term PA analysis conducted for the Proposed Action and Action Alternatives 1, 2, and 3 are provided in this section.

H.7.1 Results for the Proposed Action

The four cases below were analyzed for the Proposed Action. The cases considered the following conditions:

- Case 1 considered undisturbed repository performance. Median parameter values were used for all input variables where probability distributions had been defined.
- Case 2 considered an intrusion resulting from exploratory drilling. It was assumed that the repository would be penetrated and the drill would intercept a pressurized brine pocket in the Castile Formation. Median parameter values were used.
- Case 3 considered undisturbed repository performance. Seventy-fifth percentile parameter values were used for all input variables where probability distributions had been defined.
- Case 4 considered the same disturbed conditions as Case 2. Seventy-fifth percentile parameter values were used.

H.7.1.1 Impacts of Undisturbed Conditions

Cases 1 through 4 were simulated with the BRAGFLO code to produce brine and gas pressure fields and flow velocity fields for use in subsequent transport and direct-release calculations. Brine pressures at each time step simulated by BRAGFLO were extracted and averaged, with respect to volume, for a single panel. The average pressures show the time evolution of brine pressure predicted for the repository. The resulting pressure curves, as a function of post-closure time, are depicted in Figure H-8.

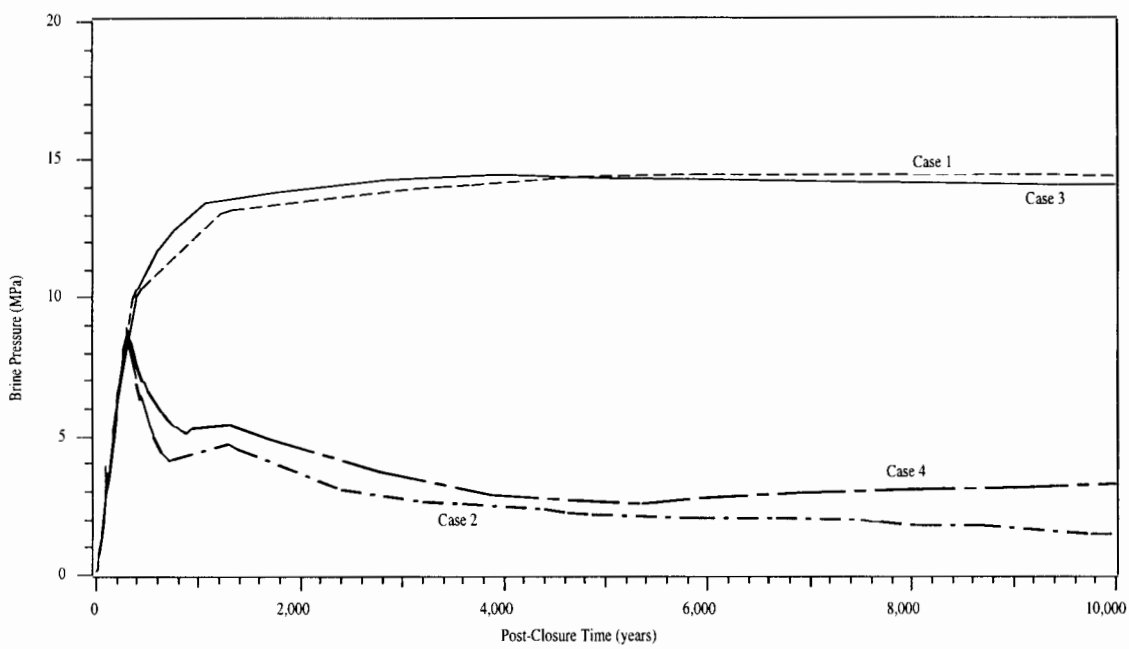


Figure H-8
Volume-Averaged Brine Pressures in a Waste Panel for the Proposed Action

The pressure release of the waste panel, as a result of the exploratory drilling event at 100 years post-closure, is clearly evident for Cases 2 and 4 in Figure H-8. Brine pressures in the panel remain below lithostatic conditions at 10,000 years post-closure for the intrusion cases. Biodegradable material is completely consumed in the gas generation process for all four cases, and the iron inventory is completely consumed in the gas generation process for both of the intrusion cases. The gas generation for the undisturbed cases is brine-limited, and the corrosion proceeds slowly enough that not all of the iron is consumed.

The extent of radionuclide and hazardous metal (lead, mercury, beryllium, and cadmium) migration for undisturbed conditions at 10,000 years after closure for Case 3 (using 75th percentile parameters) over the model domain is presented in Figure H-9. Case 3 resulted in more extensive migration than Case 1. The dashed area in the figure indicates the location in the modeled region where the concentration of total radionuclide activity in brine (summed over 30 radionuclides) is equal to or greater than 1×10^{-15} Ci per cubic meter. This area also equates to a total radionuclide activity concentration of 1 picocurie (pCi) per liter of brine and can be used to evaluate the migration of hazardous metal concentrations in brine equal to or greater than 1×10^{-3} mg per cubic meter of brine (for a total hazardous metals concentration of one part per billion). The total hazardous metal concentration represents the summed concentration of lead, mercury, beryllium, and cadmium. However, because lead is by far the predominate hazardous metal in the analyzed inventory (see Appendix A), this total hazardous metal concentration can be interpreted to approximate the predicted concentration of lead only.

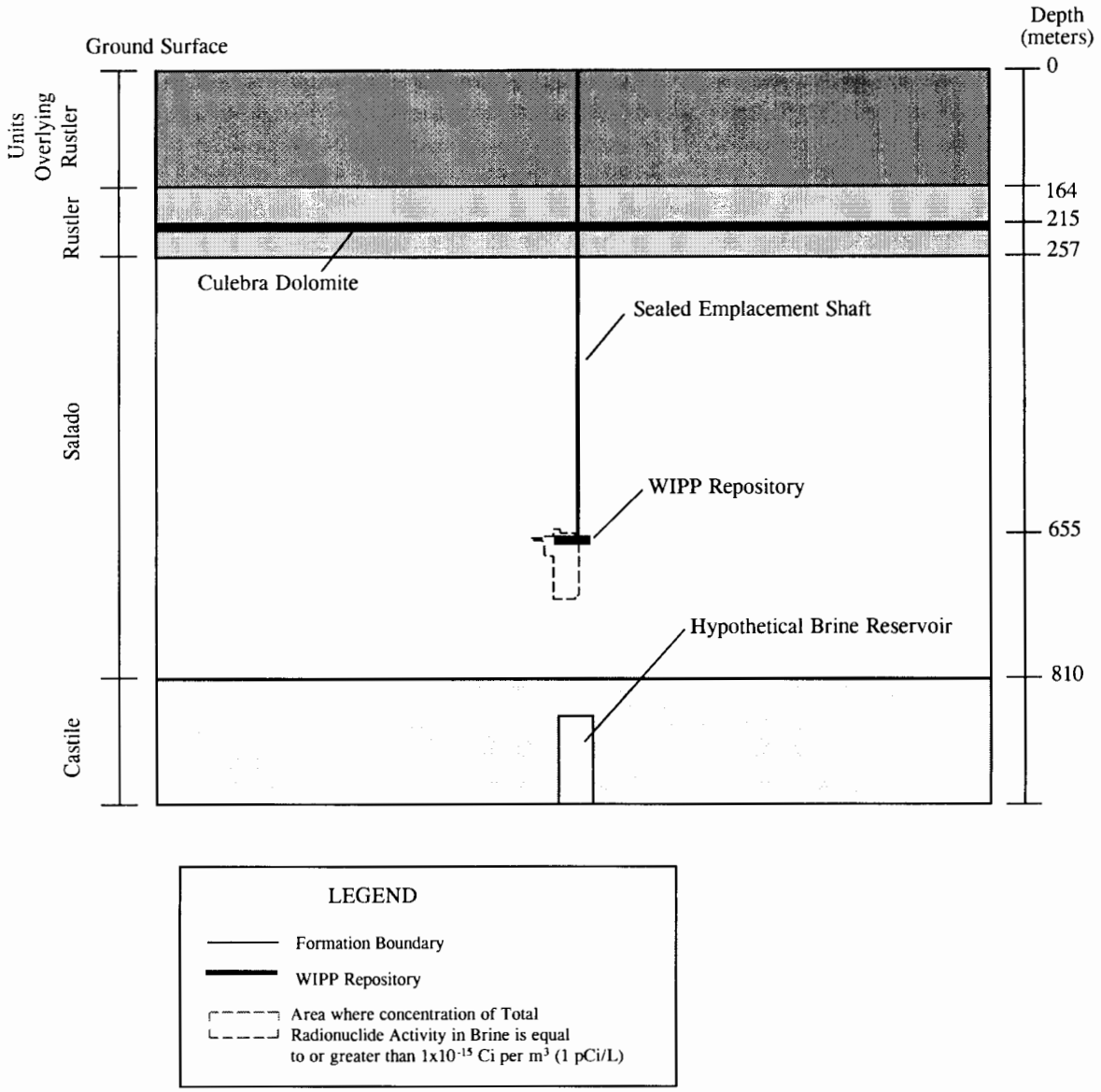
The total vertical scale of the modeled region in Figure H-9 is about 1,000 meters (3,280 feet), with the horizontal extent approximating 47 kilometers (29 miles).

For the Proposed Action, simulation results show downward migration of total radionuclide concentrations of 1 pCi per liter, total hazardous metal concentration of one part per billion some 60 meters (200 feet) below the repository, and lateral migration at 1,200 meters (3,940 feet) from the edge of the repository. Vertical upward migration of these same concentration levels of radionuclides and hazardous metals was simulated at about 10 meters (33 feet) above the top of the repository.

H.7.1.2 Impacts of Disturbed Conditions

As indicated in earlier discussion, drilling intrusion was analyzed at a time that would estimate the maximum health impacts to exposed individuals. The earliest possible time of intrusion was assumed to occur 100 years after closure of the repository at the end of the active institutional control period. For the Proposed Action, BRAGFLO calculations for undisturbed conditions showed a steady increase in brine pressure within the repository from about 5 to 14 megapascal during the first 2,000 years after repository closure. Given the range of potential release processes involved in the CUTTINGS-S code (see Figure H-3) for these pressure ranges, the potential impact of the repository pressure on the release of materials through the borehole and it impacts on exposed individuals at various intrusion times was examined.

CUTTINGS-S calculations were performed using pressures simulated with BRAGFLO and various intrusion times for undisturbed conditions as simulated in Cases 2 and 4. Results of these calculations estimated the amount of material and the associated radionuclide activity that would be released through the borehole to the ground surface. The radionuclide activities were then used to calculate the exposure to an individual. For this analysis, it was assumed that the individual would be a member of a drilling crew.



Note: Results show the area of concentration extending 60 meters (200 feet) below the repository, 10 meters (33 feet) above the repository, and 1,200 meters (3,940 feet) laterally from the edge of the repository.

Figure H-9
Extent of Radionuclide Migration for Undisturbed Conditions Using 75th Percentile Parameter Values (Case 3) at 10,000 Years

Material and nuclide activity releases were calculated with CUTTINGS-S at 100, 1,200 and 2,000 years after repository closure using undisturbed pressures from Case 2 and Case 4 BRAGFLO simulations. Results show that, although the amount of material released up the borehole from potential intrusions at later times increases, the released radionuclide activity would decrease because the radionuclides with short half-lives (which would contribute significantly to doses at earlier times) would have decayed to lower levels at later times. Dose calculations show that maximum exposure would occur at the earliest time of possible of intrusion (i.e., 100 years). Thus, the impacts from an assumed drilling intrusion under the Proposed Action was based on intrusions occurring at 100 years. This same assumption was also made in the drilling intrusion scenarios under Action Alternatives 1, 2, and 3.

Results also show that the use of median parameters and 75th percentile values resulted in approximately the same amount of material releases, activity releases and doses for any given time of intrusion. This is an indication that hydrologic parameters changed to increase repository pressures and that radionuclide transport would have less effect on the impacts of intrusion. Only the concentration of radionuclides and hazardous material in the repository material which was penetrated by intrusion and the size of intruding borehole would have an impact on the results. These parameters, however, are considered constant in that the inventory for each alternative is specified in Appendix A and the size of the intruding borehole is specified by general accepted practices.

Direct Releases

Under the Proposed Action, the estimated release to the ground surface from a drilling intrusion 100 years after WIPP closure would be 8.8 curies. Releases were mainly from Pu-238, Pu-239, and Am-241. Hazardous metal releases from an intrusion were estimated at 18.7 and 1.6 kilograms (41 and 4 pounds) of lead and mercury, respectively. These figures were based on the BRAGFLO results for Cases 2 and 4. Detailed results of these analyses are provided in Tables H-24 and H-25.

Impacts of Drilling into the Repository to the Drilling Crew Member

Using BRAGFLO results for Cases 2 and 4, radiological impacts to the drilling crew member from a drilling intrusion resulted in 3.7×10^{-4} LCF. The pathway of highest dose from the exposure was ingestion of drill cuttings. The radionuclide contributing the greatest impact (approximately 87 percent) was Am-241. Detailed results of this analysis are presented in Table H-26.

The drilling crew member may also ingest hazardous metals (lead, beryllium, cadmium, and mercury) in the drill cuttings. The crew member was assumed to ingest 100 milligrams of cuttings per day at an average concentration derived from putting all of the hazardous metals into the top 15 centimeters (6 inches) of a 10 meter by 10 meter (33 foot by 33 foot) cuttings disposal pile. There would be a 4×10^{-6} probability of cancer incidence to the drill crew member. There would be no noncarcinogenic impacts from ingestion of the metals, since all hazard indexes were far less than one (Table H-27).

Table H-24
Direct Radionuclide Releases (Ci) to the Ground Surface for an Intrusion Event Occurring at 100 Years Post-Closure for the Proposed Action

Radionuclide	Median Parameters	75th Percentile Parameters
Ac-227	1.1E-6	1.1E-6
Am-241	1.9	1.9
Cm-243	4.8E-5	4.8E-5
Cm-244	6.3E-4	6.3E-4
Cs-137	0.04	0.04
Pa-231	1.5E-6	1.5E-6
Pb-210	5.3E-5	5.3E-5
Pu-238	3.5	3.5
Pu-239	3.1	3.1
Pu-240	7.8E-5	7.8E-5
Pu-241	0.09	0.09
Sr-90	0.04	0.04
U-232	5.65E-5	5.6E-5
U-233	9.6E-03	9.6E-03
U-234	3.3E-3	3.3E-3
Y-90	0.04	0.04
Total	8.8	8.8

Table H-25
Mass Releases (kilograms) of Hazardous Metals to the Ground Surface for an Intrusion Event Occurring at 100 Years Post-Closure for the Proposed Action

Metal	Mass (kilograms)
Lead	18.7
Beryllium	0.1
Cadmium	1.4E-3
Mercury	1.6
Total	2

Table H-26
Dose (rem) to a Member of the Drilling Crew for a Drilling Intrusion Occurring at 100 Years Post-Closure for the Proposed Action

Radionuclide	Ingestion	External	Total
Am-241	0.6	0.02	0.6
Cs-137	1.8E-4	0.06	0.06
Pu-238	0.02	1.8E-4	0.02
Pu-239	0.02	3.4E-4	0.02
Y-90	4.5E-5	6.9E-4	7.3E-4
Sr-90	5.1E-4	1.2E-5	5.2E-4
Cm-244	1.2E-4	2.5E-8	1.2E-4
Pb-210	2.7E-5	4.2E-8	2.7E-5
U-233	2.4E-5	3.6E-6	2.7E-5
Cm-243	1.1E-5	1.1E-5	2.2E-5
U-234	8.0E-6	4.7E-7	8.5E-6
Pu-241	6.2E-6	7.7E-12	6.2E-6
Total (rem)	0.65	0.08	0.73
Total (LCF)	3.3E-4	4.1E-5	3.7E-4

Table H-27
Cancer Incidence and Hazard Indices from Ingestion of Metals for Drilling Intrusion into the Repository for the Proposed Action

Mixed CH-TRU and RH-TRU Waste Panel	Cancer Incidence	Hazard Index
Beryllium	3.77E-07	1.08E-05
Cadmium	7.93E-08	1.55E-06
Lead	---	7.42E-03
Mercury	---	3.05E-03

The drilling crew member would also be exposed to VOCs if the drilling occurred at a later time (e.g., 1,200 years post-closure) when higher gas pressures could cause mud blowout. In such a case, the drill crew member would inhale gas from the borehole for the short period of time before taking protective action. The concentration of VOCs to which the driller would be exposed would not be higher than the concentration in the depths of the repository. The same sampling data used to derive the VOC concentration used in the transportation accidents were used to set a time-invariant boundary condition for the long-term performance assessment calculations. Therefore, the exposures for the drilling crew member would not be expected to be worse than those experienced in the bounding WIPP facility accident for the MEI or maximally exposed noninvolved worker. Based on information presented in Section 5.1.10, the hazardous chemical impacts would be a 1×10^{-6} percent chance of cancer incidence and no noncarcinogenic health effects, since only 2×10^{-3} percent of an IDLH-equivalent quantity would be inhaled.

Impacts of Drilling into the Repository to the Well-Site Geologist

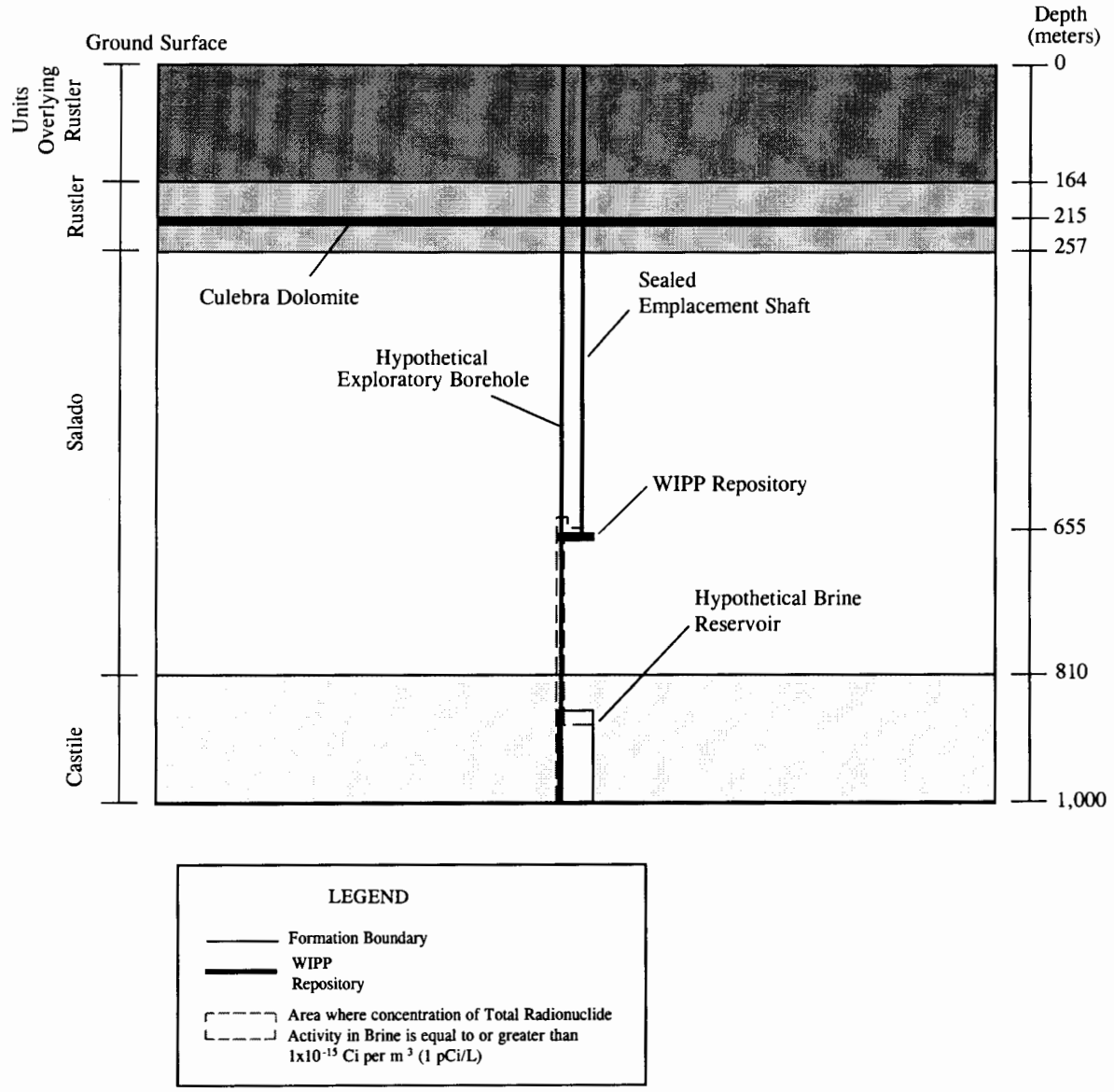
Using BRAGFLO results for Cases 2 and 4, radiological impacts to the well-site geologist based on external exposures to materials released into drill tailings both resulted in 4.4 x 10^{-9} LCF for CH-TRU waste exposures and 2.9 x 10^{-7} LCF for RH-TRU waste exposures. Detailed results of this analysis for Case 4 are presented in Table H-28.

Table H-28
External Dose (rem) for the Well-Site Geologist for a Drilling Intrusion Occurring at 100 Years Post-Closure for the Proposed Action

CH-TRU Waste		RH-TRU Waste	
Radionuclide	**External Dose**	**Radionuclide**	**External Dose**
Am-241	5.8E-6	Sr-90	4.2E-4
U-234	1.3E-6	Cs-137	1.6E-4
Sr-90	1.1E-6	Am-241	1.2E-6
Cs-137	3.0E-7	Th-231	5.5E-7
Pu-238	9.0E-8	U-234	5.4E-7
Pu-239	7.6E-8	Eu-152	5.2E-7
U-233	4.5E-8	Y-90	6.0E-8
Rn-222	2.5E-8	Cm-243	4.0E-8
Pa-233	2.1E-8	U-233	2.6E-8
Pu-240	1.5E-8	Th-234	2.1E-8
Th-228	1.4E-8	Eu-154	1.8E-8
Th-234	1.1E-8	Th-228	1.5E-8
Total (rem)	8.8E-6	Total (rem)	5.8E-4
Total (LCF)	4.4E-9	Total (LCF)	2.9E-7

Impacts of Borehole Intrusion into Pressurized Brine Reservoir

The extent of radionuclide and hazardous metal (predominately lead) migration for disturbed conditions at 10,000 years after closure for Case 4 (using 75th percentile parameters) is schematically presented in Figure H-10. Case 4 resulted in total radionuclide concentrations of 1 pCi per liter and hazardous metal concentrations of one part per billion migrating upward and downward into the exploratory borehole. As radionuclides and hazardous metals migrate in the borehole, they also penetrate the rocks directly in contact with the borehole for a limited distance. At 10,000 years, migration extends upward in the borehole at 20 meters (66 feet) above the repository. Migration also extends downward in the borehole to the Castile Formation and into the brine reservoir. This would occur after the initial pressure in the brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole over the 10,000-year simulation.



Note: Results show the area of concentration extending upward 20 meters (66 feet) and downward to the Castile Formation and into the brine reservoir.

Figure H-10
Extent of Radionuclide Migration for Disturbed Conditions Using 75th Percentile Parameter Values (Case 4) at 10,000 Years

Impacts of Potash Mining

Results for the Proposed Action (and other action alternatives) indicated that radionuclide and hazardous chemical releases from the repository would not reach the Culebra Dolomite for either undisturbed or disturbed (borehole intrusion into the repository and a pressurized brine reservoir) conditions. Thus, the impacts of potash mining on long-term performance suggested in 40 CFR Part 194 were not evaluated for the Proposed Action and other action alternatives.

H.7.2 Results for Action Alternative 1

Analyses of the long-term impacts from WIPP for Action Alternative 1 were conducted using the same computer models as were used for the Proposed Action analyses. The radionuclide and hazardous metal inventories were increased from those used in the Proposed Action to account for the increased inventory destined for WIPP under this alternative. Totals of 7.2×10^6 Ci of CH-TRU waste and 5.1×10^6 Ci of RH-TRU waste were included for this alternative. The repository size was adjusted from 10 panels (for the Proposed Action) to 68 panels. The material properties outside the repository were not changed from the comparable cases analyzed for the Proposed Action.

The four cases below were analyzed for Action Alternative 1. The cases considered the following conditions:

- Case 6 considered undisturbed repository conditions. Median parameter values were used for all input variables where probability distributions had been defined.
- Case 7 considered disturbed conditions where a borehole from exploratory drilling is assumed breach repository and penetrate a pressurized brine pocket in the Castile Formation. Median parameters values were used.
- Case 8 considered undisturbed repository conditions with 75th percentile parameter values for all input variables where probability distributions had been defined.
- Case 9 considered the same disturbed conditions as Case 7. Seventy-fifth percentile parameter values were used.

H.7.2.1 Impacts of Undisturbed Conditions

Cases 6 through 9 were simulated with the BRAGFLO code to produce brine and gas pressure fields and flow velocity fields for use in subsequent transport and direct-release calculations. Brine pressures at each time step simulated by BRAGFLO were extracted and averaged, with respect to volume, for a single panel. The average pressures show the time evolution of brine pressure predicted for the repository. The resulting pressure curves, as a function of post-closure time, are depicted in Figure H-11.

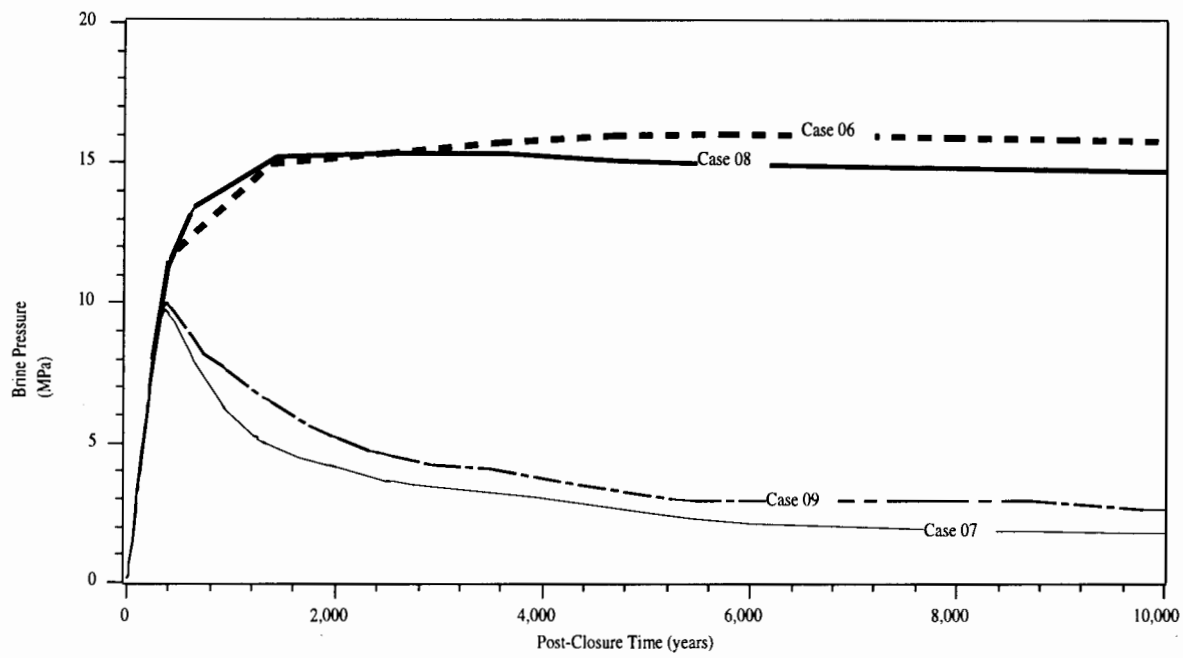
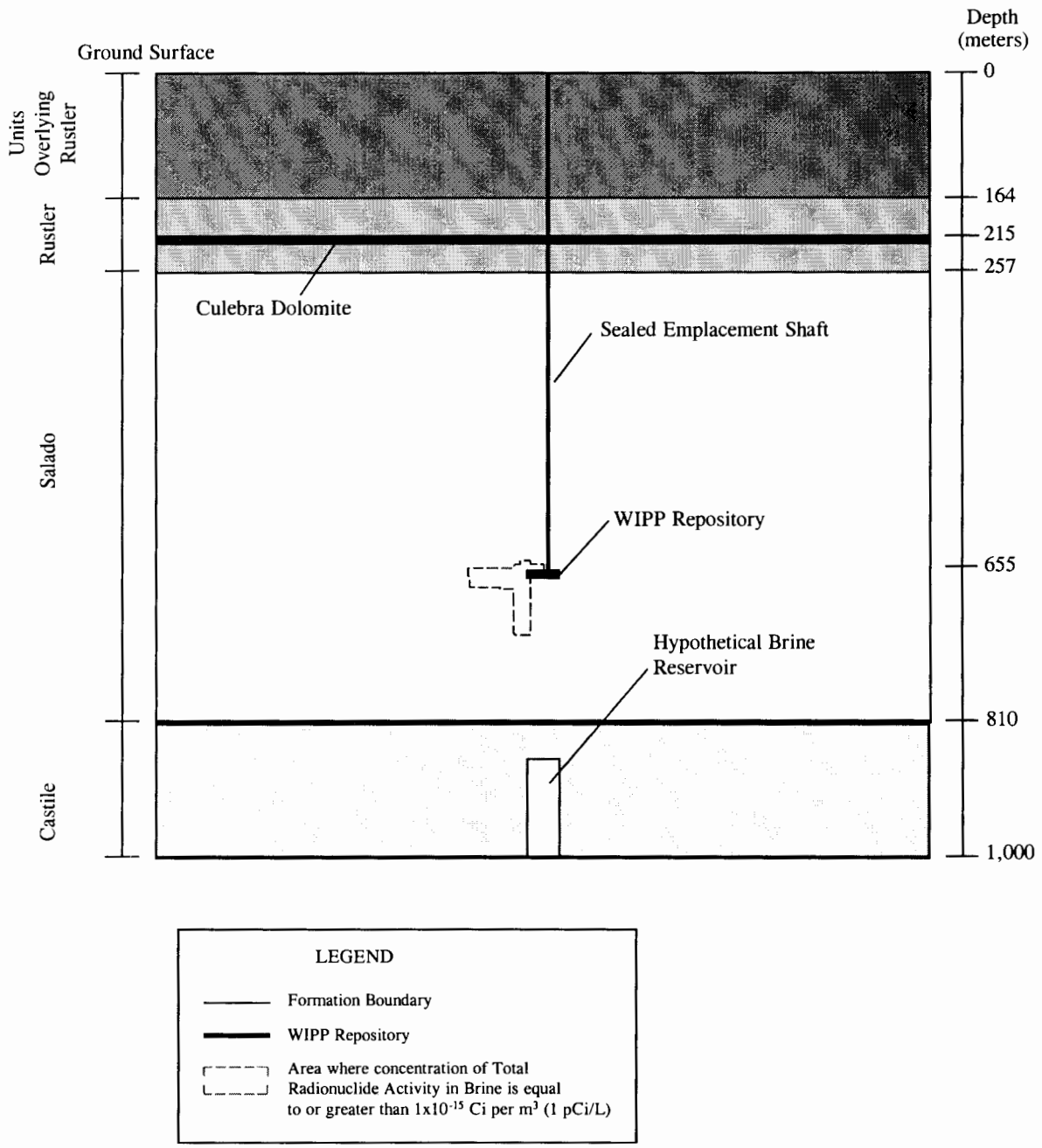


Figure H-11
Volume-Averaged Brine Pressures in a Waste Panel for Action Alternative 1

The pressure release of the waste panel as a result of the exploratory drilling event at 100 years post-closure is clearly evident for Cases 7 and 9 in this figure. Brine pressures in the panel remain below lithostatic conditions at 10,000 years post-closure for the intrusion cases. The biodegradable material is completely consumed in the gas generation process for all four cases. The iron inventory is completely consumed in the gas generation process for both of the intrusion cases. The gas generation for the undisturbed cases is brine-limited, and the corrosion proceeds slowly enough that not all of the iron is consumed.

The extent of radionuclide and hazardous metals (predominately lead) migration for undisturbed conditions at 10,000 years after closure for Case 8 (using 75th percentile parameters) is presented in Figure H-12. Case 8 is presented since it resulted in more extensive migration than Case 6. For undisturbed conditions, results from Action Alternative 1 simulations showed about the same amount of downward radionuclide and hazardous metal migration as the Proposed Action. Migration of total radionuclide concentrations of 1 pCi per liter and total hazardous metals concentrations of 1 part per billion extent about 60 meters (200 feet) below the repository. Lateral migration from the edge of the repository into local marker beds and anhydrite and halite units were also more extensive that predicted for the Proposed Action. The maximum distance of lateral migration of the same concentration levels was about 3,600 meters (11,800 feet). The maximum extent of vertical upward migration was calculated to be about 15 meters (50 feet) above the top of the repository.



Note: Results show the area of concentration extending 60 meters (200 feet) below the repository, 15 meters (50 feet) above the repository, and 3,600 meters (11,800 feet) laterally from the edge of the repository.

Figure H-12
Extent of Radionuclide Migration for Undisturbed Conditions Using 75th Percentile Parameter Values (Case 8) at 10,000 Years

H.7.2.2 Impacts of Disturbed Conditions

To bound the impacts from the drilling intrusion under Action Alternative 1, the time of the intrusion was performed at 100 years after repository closure. The intrusion was analyzed at this time to estimate the maximum health impacts to exposed individuals (see Section H.7.1.2). The following section describes the impacts of drilling into the repository and of drilling through the repository, penetrating a pressurized brine reservoir below the repository under Action Alternative 1.

Direct Releases

Under Action Alternative 1, the estimated release to the ground surface from a drilling intrusion would be 6.5, 0.4, 6.8 curies for CH-TRU waste panels, RH-TRU waste panels, and mixed CH-TRU and RH-TRU waste panels, respectively. Releases were mainly from Pu-238, Pu-239, and Am-241. Hazardous metal releases from an intrusion were estimated at 4.8, 17.6, and 18.1 kilograms (11, 40, and 40 pounds) for CH-TRU waste panels, RH-TRU waste panels, and mixed CH-TRU and RH-TRU waste panels, respectively. These figures were based on the BRAGFLO results for Cases 7 and 9. Detailed results of these analyses are provided in Tables H-29 and H-30.

Table H-29
Direct Radionuclide Releases (Ci) to the Ground Surface for an Intrusion Event Occurring at 100 Years Post-Closure for Action Alternative 1

	Median Parameters			75th Percentile Parameters		
Radionuclide	CH-TRU Waste Panel	RH-TRU Waste Panel	CH-TRU and RH-TRU Waste Panel	CH-TRU Waste Panel	RH-TRU Waste Panel	CH-TRU and RH-TRU Waste Panel
Ac-227	6.9E-8	5.7E-7	4.5E-7	6.9E-8	5.6E-7	4.5E-7
Am-241	1.4	0.05	1.5	1.4	0.05	1.4
Cm-243	8.1E-7	2.5E-5	1.8E-5	8.0E-7	2.5E-5	1.8E-5
Cm-244	3.7E-4	4.2E-5	4.0E-4	3.7E-4	4.2E-5	4.0E-4
Cs-137	1.8E-3	0.1	0.07	1.7E-3	0.1	0.07
Pa-231	9.9E-8	8.1E-7	6.4E-7	9.9E-8	8.1E-7	6.4E-7
Pb-210	2.9E-5	2.1E-9	2.9E-5	2.9E-5	2.0E-9	2.9E-5
Pu-238	2.7	3.3E-3	2.7	2.7	3.3E-03	2.7
Pu-239	2.3	0.05	2.3	2.3	0.05	2.3
Pu-240	4.6E-5	5.2E-6	5.0E-5	4.6E-5	5.2E-6	4.9E-5
Pu-241	0.05	5.6E-3	0.06	0.05	5.6E-3	0.06
Sr-90	2.1E-3	0.1	0.07	2.1E-3	0.1	0.07
U-232	7.4E-5	1.3E-6	7.5E-5	7.4E-5	1.3E-6	7.4E-5
U-233	0.01	1.7E-4	0.01	0.01	1.7E-4	0.01
U-234	2.8E-3	1.9E-4	2.9E-3	2.8E-3	1.9E-4	2.9E-3
Y90	2.1E-3	0.1	0.07	2.1E-3	0.1	0.07
Total	6.5	0.4	6.8	6.5	0.4	6.8

Table H-30
Mass Releases (kilograms) of Hazardous Metals to the Ground Surface for an Intrusion Event Occurring at 100 Years Post-Closure for Action Alternative 1

Metal	CH-TRU Waste Panel	RH-TRU Waste Panel	CH-TRU and RH-TRU Waste Panel
Lead	3.3	17.5	16.6
Beryllium	0.08	4.6E-3	0.08
Cadmium	1.2E-3	6.5E-5	1.2E-3
Mercury	1.4	0.08	1.5
Total	4.8	17.6	18.1

Impacts of Drilling into the Repository to the Drilling Crew Member

Using BRAGFLO results for Cases 7 and 9, radiological impacts to the drilling crew member from a drilling intrusion resulted in 3.3 x 10^{-4} LCF (see Table H-31). The pathway of highest dose from the exposure was ingestion of drill cuttings. The radionuclide contributing the greatest impact (approximately 87 percent) was Am-241.

The estimated maximum impacts from carcinogenic metals, expressed as a mathematical expectation of cancer, would be 4.3 x 10^{-6}, 1.6 x 10^{-5}, and 9.4 x 10^{-7} for intrusion into mixed CH-TRU and RH-TRU waste panels, CH-TRU waste only panels, and RH-TRU waste only panels, respectively (Table H-32). The hazard indices for all the metals (lead, beryllium, cadmium, and mercury) ingested, which were well below one, would suggest there would be no noncarcinogenic health impacts.

Impacts of Drilling into the Repository to the Well-Site Geologist

Using BRAGFLO results for Cases 7 and 9, radiological impacts to the well-site geologist based on external exposures to materials released into drill tailings both resulted in 3.8 x 10^{-9} LCF for CH-TRU waste exposures and 4.2 x 10^{-7} LCF for RH-TRU waste exposures. Detailed results of this analysis for Case 9 are presented in Table H-33.

Impacts of Borehole Intrusion into Pressurized Brine Reservoir

The extent of radionuclide and hazardous metal (predominately lead) migration for disturbed conditions at 10,000 years after closure for Case 9 (using 75th percentile parameters) would be very similar to results simulated for Case 4, see Figure H-10. At 10,000 years, migration within the borehole and outward into the surrounding salt beds around the borehole extends upward about 20 meters (66 feet) above the repository. Migration would also extend downward in the borehole and surrounding rocks to the Castile Formation and into the brine reservoir. As in the Proposed Action and Action Alternative 1, this would occur after the initial pressure in the pressurized brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole over the 10,000-year simulation.

H.7.3 Results for Action Alternative 2

Analyses of the long-term impacts from WIPP for Action Alternative 2 were conducted using the same computer models as were used for the Proposed Action analyses. The radionuclide and hazardous metal inventories were increased to account for the increased inventory destined for

Table H-31
Dose (rem) to a Member of the Drilling Crew for a Drilling Intrusion Occurring at 100 Years Post-Closure for Action Alternative 1

Radionuclide	Ingestion	External	Total
CH-TRU Waste Panel			
Am-241	0.5	0.02	0.5
Pu-238	0.01	1.3E-4	0.01
Pu-239	0.01	2.5E-4	0.01
Cs-137	8.1E-6	2.6E-3	2.6E-3
Cm-244	7.2E-5	1.5E-8	7.2E-5
Y-90	2.2E-6	3.2E-5	3.4E-5
U-233	2.5E-5	3.6E-6	2.8E-5
Sr-90	2.4E-5	5.8E-7	2.5E-5
Pb-210	1.4E-5	2.3E-8	1.4E-5
U-234	6.5E-6	3.9E-7	6.9E-6
Pu-241	3.9E-6	4.8E-12	3.9E-6
U-232	4.7E-7	1.8E-8	4.9E-7
Total (rem)	0.5	0.02	0.52
Total (LCF)	2.5E-4	9.5E-6	2.6E-4
RH-TRU Waste Panel			
Cs-137	4.7E-4	0.02	0.2
Am-241	0.02	4.9E-4	0.02
Y-90	9.7E-5	1.5E-3	1.6E-3
Sr-90	1.1E-3	2.6E-5	1.1E-3
Pu-239	2.3E-4	5.3E-6	2.4E-4
Pu-238	1.5E-5	1.6E-7	1.5E-5
Cm-243	6.0E-6	5.8E-6	1.2E-5
Cm-244	7.8E-6	1.6E-9	7.8E-6
Pa-231	8.1E-7	5.8E-8	8.7E-7
Ac-227	7.5E-7	1.1E-10	7.5E-7
U-234	4.9E-7	2.9E08	5.2E-7
U-233	4.5E-7	6.7E-8	5.1E-7
Total (rem)	0.02	0.2	0.22
Total (LCF)	8.5E-6	7.6E-5	8.5E-5
CH-TRU and RH-TRU Waste Panel			
Am-241	0.5	0.02	0.52
Cs-137	3.2E-4	0.1	0.1
Pu-238	0.02	1.3E-4	0.02
Pu-239	0.01	2.6E-4	0.01
Y-90	6.7E-5	1.0E-3	1.1E-3
Sr-90	7.5E-4	1.8E-5	7.7E-4
Cm-244	7.6E-5	1.6E-8	7.6E-5
U-233	2.5E-5	3.6E-6	2.8E-5
Pb-210	1.4E-5	2.3E-8	1.4E-5
Cm-243	4.3E-6	4.1E-6	8.4E-6
U-234	7.0E-6	4.2E-7	7.4E-6
Pu-241	4.0E-6	5.0E-12	4.0E-6
Total (rem)	0.5	0.12	0.65
Total (LCF)	2.7E-4	5.9E-5	3.3E-4

Table H-32
Cancer Incidence and Hazard Indices from Ingestion of Metals for Drilling Intrusion into the Repository for Action Alternative 1

Mixed CH-TRU and RH-TRU Waste Panel	Cancer Incidence	Hazard Index
Beryllium	4.26E-06	2.83E-06
Cadmium	9.61E-08	4.36E-07
Lead	---	2.09E-03
Mercury	---	8.58E-04
CH-TRU Waste Only Panel		
Beryllium	1.55E-05	1.03E-05
Cadmium	3.51E-07	1.59E-06
Lead	---	1.57E-03
Mercury	---	3.13E-03
RH-TRU Waste Only Panel		
Beryllium	9.22E-07	6.13E-07
Cadmium	1.93E-08	8.74E-08
Lead	---	8.38E-03
Mercury	---	1.73E-04

Table H-33
External Dose (rem) for the Well-Site Geologist for a Drilling Intrusion Occurring at 100 Years Post-Closure for Action Alternative 1

CH-TRU Waste		RH-TRU Waste	
Radionuclide	**External Dose**	**Radionuclide**	**External Dose**
Am-241	5.0E-6	Sr-90	5.8E-4
U-234	1.1E-6	Cs-137	2.6E-4
Sr-90	9.1E-7	Am-241	2.1E-6
Cs-137	3.1E-7	U-234	9.6E-7
Pu-238	7.0E-8	Th-231	1.8E-7
Pu-239	6.1E-8	Eu-152	1.7E-7
U-233	5.2E-8	Y-90	8.4E-8
Th-228	2.3E-8	Pu-239	1.8E-8
Rn-222	1.5E-8	Cm-243	1.4E-8
Th-234	1.2E-8	U-233	1.2E-8
Pa-233	1.1E-8	Th-234	8.2E-9
Pu-240	1.1E-8	Pu-240	6.8E-9
Total (rem)	7.6E-6	Total (rem)	8.4E-4
Total (LCF)	3.8E-9	Total (LCF)	4.2E-7

WIPP. Totals of 7.3 x 10^6 Ci of CH-TRU waste and 5.1 x 10^6 Ci of RH-TRU waste were included for this alternative. Detailed information on the radionuclide and hazardous material inventories are provided in Appendix A. The repository size was adjusted from the 10 panels (for the Proposed Action) to 75 panels. The material properties outside the repository were not changed from the comparable cases analyzed for the Proposed Action.

The four cases below were analyzed for Action Alternative 2. The cases considered the following conditions:

- Case 11 considered undisturbed repository performance. Median parameter values were used for all input variables where probability distributions had been defined.
- Case 12 considered disturbed conditions where a borehole from exploratory drilling is assumed to breach the repository and penetrate a pressurized brine pocket in the Castile Formation. Median parameters were used.
- Case 13 considered undisturbed repository performance. Seventy-fifth percentile parameter values were used for all input variables where probability distributions had been defined.
- Case 14 considered the same disturbed conditions as Case 12. Seventy-fifth percentile parameter values were used.

H.7.3.1 Impacts of Undisturbed Conditions

Cases 11 through 14 were simulated using the BRAGFLO code to produce brine and gas pressure fields and flow velocity fields for use in subsequent transport and direct-release calculations. Brine pressures at each time step simulated by BRAGFLO were extracted and averaged, with respect to volume, for a single panel. The average pressures show the time evolution of brine pressure predicted for the repository. The resulting pressure curves, as a function of post-closure time, are depicted in Figure H-13.

The pressure release of the waste panel as a result of the exploratory drilling event at 100 years post-closure is clearly evident for Cases 12 and 14 in this figure. Brine pressures in the panel remain below lithostatic conditions at 10,000 years post-closure for all cases. The notable change for this alternative relative to all the other alternatives was that the thermal processing was assumed to destroy all of the biodegradable material that contributes to gas generation. The iron corrosion was assumed to still occur. The iron inventory is completely consumed in the gas generation process for both of the intrusion cases. The gas generation for the undisturbed cases is brine-limited, and the corrosion proceeds slowly enough that not all of the iron is consumed.

The extent of radionuclide and hazardous metal (predominately lead) migration for undisturbed conditions at 10,000 years after closure for Case 13 (using 75th percentile parameters) is schematically presented in Figure H-14. Case 13 is presented since it resulted in more extensive migration than Case 11. Simulation results show very limited vertical and lateral migration compared to results from the Proposed Action and Action Alternative 1. The more competent waste form resulting from thermal treatment limits the migration of radionuclides beyond the DRZ just above, below, and laterally from the repository. Vertical migration of total radionuclide concentrations of 1 pCi per liter and total hazardous metals concentrations of one part per billion was estimated at about 15 meters (50 feet) below the bottom of the repository and about 7 meters

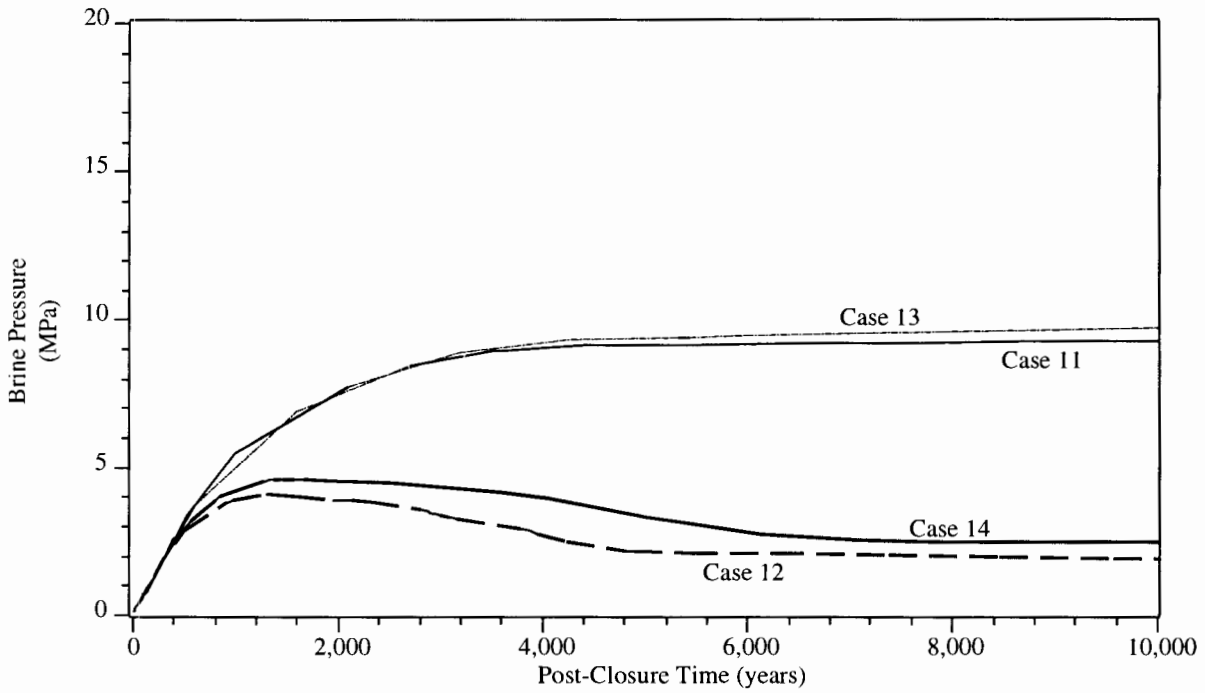


Figure H-13
Volume-Averaged Brine Pressures in a Waste Panel for Action Alternative 2

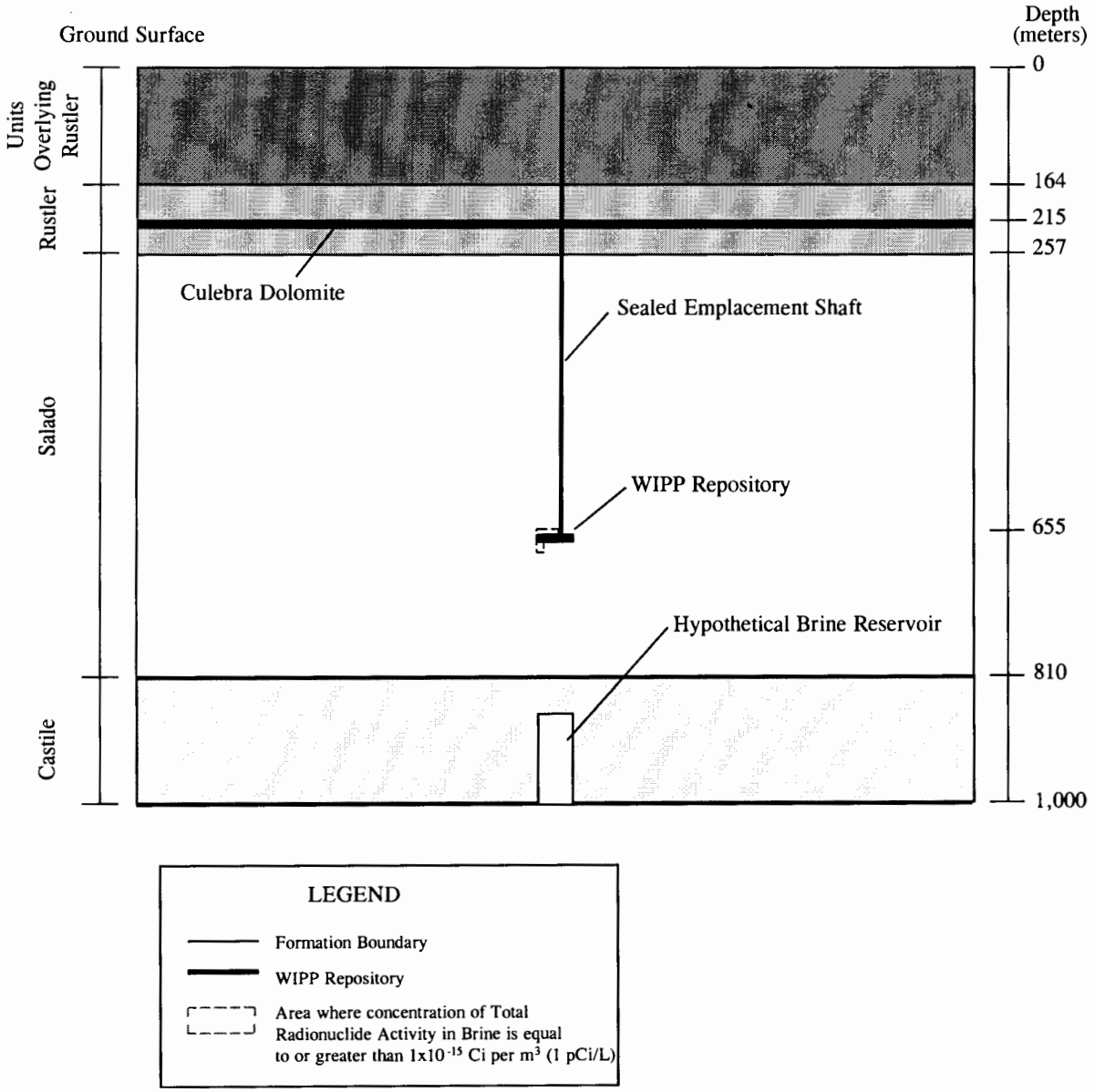
(23 feet) above the top of the repository. Some lateral migration at these concentration levels is simulated although it is not evident in Figure H-14.

H.7.3.2 Impacts of Disturbed Conditions

To bound the impacts from the drilling intrusion under Action Alternative 2, the time of the intrusion was performed at 100 years after repository closure. The intrusion was analyzed at this time to estimate the maximum health impacts to exposed individuals (see Section H.7.1.2). The following section describes the impacts of drilling into the repository, and of drilling through the repository, penetrating a pressurized brine reservoir below the repository under Action Alternative 2.

Direct Releases

Under Action Alternative 2, the estimated release to the ground surface from a drilling intrusion would be 11 and 0.3 curies for CH-TRU waste and RH-TRU waste panels, respectively. Releases were mainly from Pu-238, Pu-239, and Am-241. Hazardous metal releases from an intrusion were estimated at 8.1 and 77.7 kilograms (18 and 171 pounds) for CH-TRU waste and RH-TRU waste panels, respectively. These figures were based on the BRAGFLO results for Cases 12 and 14. Detailed results of these analyses are provided in Tables H-34 and H-35.



Note: Results show the area of concentration extending 15 meters (50 feet) below the repository, 7 meters (23 feet) above the repository, and 90 meters (295 feet) laterally from the edge of the repository.

Figure H-14
Extent of Radionuclide Migration for Undisturbed Conditions Using 75th Percentile Parameter Values (Case 13) at 10,000 Years

Table H-34
Direct Radionuclide Releases (Ci) to the Ground Surface for an Intrusion Event Occurring at 100 Years Post-Closure for Action Alternative 2

Radionuclide	Median Parameters		75th Percentile Parameters	
	CH-TRU Waste Panel	RH-TRU Waste Panel	CH-TRU Waste Panel	RH-TRU Waste Panel
Ac-227	1.2E-7	4.7E-7	1.2E-7	4.7E-7
Am-241	2.4	0.04	2.4	0.04
Cm-243	1.4E-6	2.1E-5	1.4E-6	2.1E-5
Cm-244	6.4E-4	3.5E-5	6.3E-4	3.5E-5
Cs-137	3.0E-3	0.09	3.0E-3	0.09
Pa-231	1.7E-7	6.7E-7	1.7E-7	6.7E-7
Pb-210	4.9E-5	1.7E-9	4.9E-5	1.7E-9
Pu-238	4.7	2.8E-3	4.7	2.8E-3
Pu-239	3.9	0.04	3.9	0.04
Pu-240	7.8E-5	4.4E-6	7.8E-5	4.4E-6
Pu-241	0.09	4.7E-3	0.09	4.7E-3
Sr-90	3.5E-3	0.08	3.5E-3	0.08
U-232	1.3E-4	1.1E-6	1.3E-4	1.1E-6
U-233	0.02	1.5E-4	0.02	1.5E-4
U-234	4.7E-3	1.6E-4	4.7E-3	1.6E-4
Y-90	3.5E-3	0.08	3.5E-3	0.08
Total	11.1	0.33	11.1	0.33

Table H-35
Mass Releases (kilograms) of Hazardous Metals to the Ground Surface for an Intrusion Event Occurring at 100 Years Post-Closure for Action Alternative 2

Metal	CH-TRU Waste Panel	RH-TRU Waste Panel
Lead	5.6	77
Beryllium	0.1	0.02
Cadmium	2.0E-3	2.9E-4
Mercury	2.4	0.3
Total	8.1	77.7

Impacts of Drilling into the Repository to the Drilling Crew Member

Using BRAGFLO results for Cases 12 and 14, radiological impacts to the drilling crew member from a drilling intrusion resulted in 4.5 x 10^{-4} LCF and 7.3 x 10^{-5} LCF for CH-TRU and RH-TRU waste panels, respectively (see Table H-36). The pathway of highest dose from the exposure was ingestion of drill cuttings. The radionuclide contributing the greatest impact (approximately 87 percent) was Am-241.

The estimated maximum impacts from carcinogenic metals, expressed as a mathematical expectation of cancer, would be 2.6 x 10^{-5} and 3.7 x 10^{-6} for intrusions in CH-TRU waste only panels, and RH-TRU waste only panels, respectively (Table H-37). As for the other alternatives, the hazard indices for the metals ingested, which were well below one, would suggest there would be no noncarcinogenic health impacts.

Table H-36
Dose (rem) to a Member of the Drilling Crew for a Drilling Intrusions Occurring at 100 Years Post-Closure for Action Alternative 2

Radionuclide	CH-TRU Waste Panel			Radionuclide	RH-TRU Waste Panel		
	Ingestion	External	Total		Ingestion	External	Total
Am-241	0.84	0.03	0.90	Cs-137	3.9E-4	0.13	0.13
Pu-238	0.02	2.3E-4	0.02	Am-241	0.01	4.2E-4	0.01
Pu-239	0.02	4.2E-4	0.02	Y-90	8.0E-5	1.2E-3	1.3E-3
Cs-137	1.3E-5	4.3E-3	4.3E-3	Sr-90	9.0E-4	2.1E-5	9.2E-4
Cm-244	1.2E-4	2.5E-8	1.2E-4	Pu-239	1.9E-4	4.5E-6	2.0E-4
Y-90	3.6E-6	5.4E-5	5.8E-5	Pu-238	1.2E-5	1.3E-7	1.2E-5
U-233	4.2E-5	6.4E-6	4.8E-5	Cm-243	5.0E-6	4.7E-6	9.8E-6
Sr-90	4.0E-5	9.7E-7	4.1E-5	Cm-244	6.6E-6	1.4E-9	6.6E-6
Pb-210	2.4E-5	3.8E-8	2.4E-5	Pa-231	6.8E-7	4.9E-8	7.3E-7
U-234	1.1E5	6.8E-7	1.2E-5	Ac-227	6.1E-7	9.1E-11	6.1E-7
Pu-241	6.4E-6	8.0E-12	6.4E-6	U-234	4.1E-7	2.5E-8	4.4E-7
U-232	8.1E-7	3.2E-8	8.5E-7	U-233	3.4E-7	5.3E-8	3.9E-7
Total (rem)	0.88	0.03	0.81	Total (rem)	0.01	0.13	0.14
Total (LCF)	4.4E-4	1.6E-5	4.5E-4	Total (LCF)	7.3E-6	6.6E-5	7.3E-5

Table H-37
Cancer Incidence and Hazard Indices from Ingestion of Metals for Drilling Intrusion into the Repository for Action Alternative 2

Metals	Cancer Incidence	Hazard Index
CH-TRU Waste Only Panel		
Beryllium	2.56E-05	1.70E-05
Cadmium	5.38E-07	2.44E-06
Lead	---	2.40E-03
Mercury	---	4.81E-03
RH-TRU Waste Only Panel		
Beryllium	3.63E-06	2.41E-06
Cadmium	7.58E-08	3.44E-07
Lead	---	3.30E-02
Mercury	---	6.81E-04

Impacts of Drilling into the Repository to the Well-Site Geologist

Using BRAGFLO results for Cases 12 and 14, radiological impacts to the well-site geologist based on external exposures to materials released into drill tailings both resulted in 1.0×10^{-8} LCF for CH-TRU waste exposures and 1.2×10^{-6} LCF for RH-TRU waste exposures. Detailed results of this analysis for Case 14 are presented in Table H-38.

Table H-38
External Dose (rem) for the Well-Site Geologist for a Drilling Intrusion Occurring at 100 Years Post-Closure for Action Alternative 2

CH-TRU Waste		RH-TRU Waste	
Radionuclide	**External Dose**	**Radionuclide**	**External Dose**
Am-241	1.3E-5	Sr-90	1.6E-3
U-234	3.0E-6	Cs-137	7.2E-4
Sr-90	2.4E-6	Am-241	5.8E-6
Cs-137	8.4E-7	U-234	2.6E-6
Pu-238	1.9E-7	Th-231	5.2E-7
Pu-239	1.6E-7	Eu-152	5.0E-7
U-233	1.4E-7	Y-90	2.3E-7
Th-228	5.7E-8	Pu-239	4.8E-8
Rn-222	4.1E-8	Cm-243	3.8E-8
Pa-233	3.0E-8	U-233	3.2E-8
Th-234	3.0E-8	Th-234	2.3E-8
Pu-240	3.0E-8	Pu-240	2.0E-8
Total (rem)	2.0E-5	Total (rem)	2.3E-3
Total (LCF)	1.0E-8	Total (LCF)	1.2E-6

Impacts of Borehole Intrusion into Pressurized Brine Reservoir

The extent of radionuclide and hazardous metal (predominantly lead) migration for disturbed conditions at 10,000 years after closure for Case 14 (using 75th percentile parameters) would be very similar to results simulated for Case 4, see Figure H-10. At 10,000 years, migration within the borehole and outward into the surrounding salt beds around the borehole extends upward about 20 meters (66 feet) above the repository. Migration also extends downward in the borehole and surrounding rocks to the Castile Formation and into the brine reservoir. As in the Proposed Action and Action Alternative 1, this would occur after the initial pressure in the pressurized brine pocket dissipates and equilibrates with pressures in the repository and overlying units penetrated by the borehole over the 10,000-year simulation.

H.7.4 Results for Action Alternative 3

Analysis of the long-term impacts from WIPP for Action Alternative 3 was conducted using the same computer models as were used for the Proposed Action analyses. The radionuclide and hazardous metal inventories were increased to account for the increased inventory destined for WIPP under this alternative. Totals of 7.3 x 10^6 Ci of CH-TRU waste and 5.1 x 10^6 Ci of RH-TRU waste were included. Detailed information on the radionuclide and hazardous material inventories are provided in Appendix A. Also, the repository size was adjusted from the 10 panels (for the Proposed Action) to 71 panels. The material properties outside the repository were not changed from the comparable cases analyzed for the Proposed Action.

The four cases below were analyzed for Action Alternative 3. The cases considered the following conditions:

- Case 16 considered undisturbed repository conditions. Median parameter values were used for all input variables where probability distributions have been defined.

- Case 17 considered an intrusion resulting from exploratory drilling. It was assumed that the repository would be penetrated and the drill would intercept a pressurized brine pocket in the Castile Formation. Median parameters were used.

- Case 18 considered undisturbed repository conditions. Seventy-fifth percentile parameter values were used for all input variables where probability distributions had been defined.

- Case 19 considered the same disturbed conditions as Case 17. Seventy-fifth percentile parameters values were used.

H.7.4.1 Impacts of Undisturbed Conditions

Cases 16 through 19 were simulated in BRAGFLO to produce brine and gas pressure fields and flow velocity fields for use in subsequent transport and direct-release calculations. Brine pressures at each time step simulated by BRAGFLO were extracted and averaged, with respect to volume, for a single panel. The average pressures show the time evolution of brine pressure predicted for the repository. The resulting pressure curves, as a function of post-closure time, are depicted in Figure H-15.

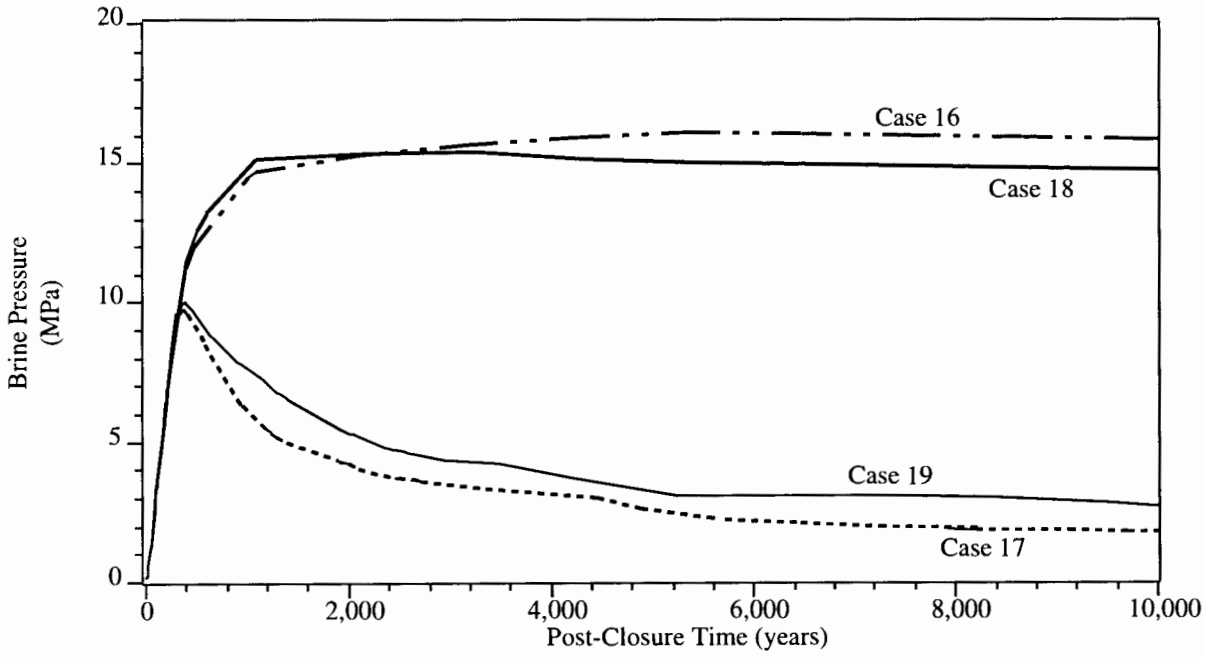


Figure H-15
Volume-Averaged Brine Pressures in a Waste Panel for Action Alternative 3

The pressure release of the waste panel as a result of the exploratory drilling event at 100 years post-closure is clearly evident for Cases 17 and 19 in this figure. Brine pressures in the panel remain below lithostatic conditions at 10,000 years post-closure for the intrusion cases. The biodegradable material is completely consumed in the gas generation process for all four cases. The iron inventory is completely consumed in the gas generation process for both of the intrusion

cases. The gas generation for the undisturbed cases is brine-limited, and the corrosion proceeds slowly enough that not all of the iron is consumed.

For Action Alternative 3, the extent of radionuclide and hazardous metals (predominantly lead) migration for undisturbed conditions at 10,000 years after closure for Case 18 (using 75th percentile parameters) are very similar to that shown for Case 8 of Action Alternative 1. For undisturbed conditions (Figure H-12), results from Action Alternative 1 simulations showed about the same amount of downward radionuclide and hazardous metal migration as the Proposed Action. Migration of total radionuclide concentrations of 1 pCi per liter and total hazardous metal concentrations of one part per billion extend about 60 meters (200 feet) below the repository. Lateral migration from the edge of the repository into local marker beds and anhydrite and halite units were also more extensive that predicted for the Proposed Action. The maximum distance of lateral migration of the same concentration levels was about 3,600 meters (11,800 feet). The maximum extent of vertical upward migration was calculated to be about 15 meters (50 feet) above the top of the repository.

H.7.4.2 Impacts of Drilling into the Repository

To bound the impacts from the drilling intrusion under Action Alternative 3, the time of the intrusion was performed at 100 years after repository closure. The intrusion was analyzed at this time to estimate the maximum health impacts to exposed individuals (see Section H.7.1.2). The following section describes the impacts of drilling into the repository and of drilling through the repository, penetrating a pressurized brine reservoir below the repository under Action Alternative 3.

Direct Releases

Under Action Alternative 3, the estimated release to the ground surface from a drilling intrusion would be 5.8, 5.6, and 0.4 curies for intrusions into mixed CH-TRU and RH-TRU waste panels, CH-TRU waste only panels, and RH-TRU waste only panels, respectively. Releases were mainly from Pu-238, Pu-239, and Am-241. Hazardous metal releases from an intrusion were estimated at 14.2, 4.0, and 17.6 kilograms (31, 9, and 40 pounds) for intrusions into mixed CH-TRU and RH-TRU waste panels, CH-TRU waste only panels, and RH-TRU waste only panels, respectively. These figures were based on the BRAGFLO results for Cases 17 and 19. Detailed results of these analyses are provided in Tables H-39 and H-40.

Impacts of Drilling into the Repository to the Drilling Crew Member

Using BRAGFLO results for Cases 17 and 19, radiological impacts to the drilling crew member from the drilling intrusion resulted in 2.6×10^{-4} LCF (see Table H-41). The pathway of highest dose from the exposure was ingestion of drill cuttings. The radionuclide contributing the greatest impact (approximately 87 percent) was Am-241.

The estimated maximum impacts from carcinogenic metals, expressed as a mathematical expectation of cancer, would be 1.4×10^{-5}, 3.0×10^{-7}, 9.5×10^{-7} for intrusion into mixed CH-TRU and RH-TRU waste panels, CH-TRU waste only panels, RH-TRU waste only panels, respectively (see Table H-42). As with the other alternatives, the hazard indices for the metals ingested, which were well below one, would suggest there would be no noncarcinogenic health impacts.

Table H-39
Direct Radionuclide Releases (Ci) to the Ground Surface for an Intrusion Event Occurring at 100 Years Post-Closure for Action Alternative 3

Radionuclide	Median Parameters			75th Percentile Parameters		
	CH-TRU Waste Panel	RH-TRU Waste Panel	CH-TRU and RH-TRU Waste Panel	CH-TRU Waste Panel	RH-TRU Waste Panel	CH-TRU and RH-TRU Waste Panel
Ac-227	5.9E-8	5.7E-7	3.8E-7	5.9E-8	5.6E-7	3.7E-7
Am-241	1.2	0.05	1.2	1.2	0.04	1.2
Cm-243	6.9E-7	2.5E-5	1.5E-5	6.8E-7	2.5E-5	1.5E-5
Cm-244	3.2E-4	4.2E-5	3.4E-4	3.2E-4	4.2E-5	3.4E-4
Cs-137	1.5E-3	0.1	0.06	1.5E-3	0.1	0.06
Pa-231	8.4E-8	8.1E-7	5.4E-7	8.4E-8	8.1E-7	5.3E-7
Pb-210	2.4E-5	2.1E-9	2.4E-5	2.4E-5	2.0E-9	2.4E-5
Pu-238	2.3	3.3E-3	2.3	2.3	3.3E-3	2.3
Pu-239	2.0	0.05	2.0	2.0	0.05	2.0
Pu-240	3.9E05	5.2E-6	4.2E-5	3.9E-5	5.2E-6	4.2E-5
Pu-241	0.05	5.6E-3	0.05	0.05	5.6E-3	0.5
Sr-90	1.8E-3	0.1	0.06	1.8E-3	0.09	0.5
U-232	6.3E-5	1.3E-6	6.4E-5	6.3E-5	1.3E-6	6.3E-5
U-233	8.6E-3	1.7E-4	8.7E-3	8.5E-3	1.7E-4	8.6E-3
U-234	2.4E-3	1.9E-4	2.5E-3	2.4E-3	1.9E-4	2.5E03
Y-90	1.8E-3	0.1	0.06	1.8E-3	0.09	0.05
Total	5.6	0.4	5.8	5.1	0.4	5.8

Table H-40
Mass Releases (kilograms) of Hazardous Metals to the Ground Surface for an Intrusion Event Occurring at 100 Years Post-Closure for Action Alternative 3

Metal	CH-TRU Waste Panel	RH-TRU Waste Panel	CH-TRU and RH-TRU Waste Panel
Lead	2.8	17.5	13
Beryllium	0.07	4.6E-3	0.07
Cadmium	1.0E-3	6.5E-5	1.1E-3
Mercury	1.2	0.08	1.2
Total	4.0	17.6	14.2

Table H-41
Dose (rem) to a Member of the Drilling Crew for a Drilling Intrusion Occurring at 100 Years Post-Closure for Action Alternative 3

Median Parameters			
Radionuclide	**Ingestion**	**External**	**Total**
CH-TRU Waste Panel			
Am-241	0.4	0.01	0.4
Pu-238	0.01	1.2E-4	0.01
Pu-239	9.5E-3	2.1E-4	9.7E-3
Cs-137	6.60E-6	2.20E-3	2.20E-3
Cm-244	6.00E-5	1.2E-8	6.0E-5
Y-90	1.8E-6	2.8E-5	3.0E-5
U-233	2.1E-5	3.2E-6	2.4E-5
Sr-90	2.1E-5	5.0E-7	2.1E-5
Pb-210	1.2E-5	1.9E-8	1.2E-5
U-234	5.9E-6	3.5E-7	6.3E-6
Pu-241	3.2E-6	4.0E-12	3.2E-6
U-232	4.0E-7	1.5E-8	4.2E-7
Total (rem)	0.4	0.02	0.42
Total (LCF)	2.1E-4	8.3E-6	2.2E-4
RH-TRU Waste Panel			
Cs-137	4.7E-4	0.2	0.2
Am-241	0.02	4.9E-4	0.02
Y-90	9.7E-5	1.5E-3	1.6E-3
Sr-90	1.1E-3	2.6E-5	1.1E-3
Pu-239	2.3E-4	5.3E-6	2.4E-4
Pu-238	1.5E-5	1.6E-7	1.5E-5
Cm-243	6.0E-6	5.8E-6	1.2E-5
Cm-244	7.8E-6	1.6E-9	7.8E-6
Pa-231	8.1E-7	5.8E-8	8.7E-7
Ac-227	7.5E-7	1.1E-10	7.5E-7
U-234	4.9E-7	2.9E-8	5.2E-7
U-233	4.5E-7	6.7E-8	5.1E-7
Total (rem)	0.02	0.2	0.22
Total (LCF)	8.5E-6	7.6E-5	8.5E-5
CH-TRU and RH-TRU Waste Panel			
Am-241	0.4	0.01	0.4
Cs-137	2.7E-4	0.09	0.09
Pu-238	0.01	1.2E-4	0.01
Pu-239	9.5E-3	2.1E-4	9.7E-3
Y-90	5.7E-5	8.5E-4	9.0E-4
Sr-90	6.4E-4	1.5E-5	6.6E-4
Cm-244	6.6E-5	1.4E-8	6.6E-5
U-233	2.2E-5	3.2E-6	2.5E-5
Pb-210	1.2E-5	1.9E-8	1.2E-5
Cm-243	3.5E-6	3.5E-6	7.0E-6
U-234	5.9E-6	3.5E-7	6.3E-6
Pu-241	3.4E-6	4.3E-12	3.4E-6
Total (rem)	0.4	0.1	0.5
Total (LCF)	2.1E-4	5.1E-5	2.6E-4

Table H-42
Cancer Incidence and Hazard Indices from Ingestion of Metals for Drilling Intrusion into the Repository for Action Alternative 3

Metals	Cancer Incidence	Hazard Index
Mixed CH-TRU and RH-TRU Waste Panel		
Beryllium	1.38E-05	9.19E-06
Cadmium	3.12E-07	1.42E-06
Lead		6.08E-03
Mercury		2.79E-03
CH-TRU Waste Only Panel		
Beryllium	1.33E-05	8.84E-06
Cadmium	3.01E-07	1.37E-06
Lead		1.34E-03
Mercury		2.69E-03
RH-TRU Waste Only Panel		
Beryllium	1.33E-05	6.19E-07
Cadmium	3.01E-07	8.83E-08
Lead		8.47E-03
Mercury		1.76E-04

Impacts of Drilling into the Repository to the Well-Site Geologist

Using BRAGFLO results for Cases 17 and 19, radiological impacts to the well-site geologist based on external exposures to materials released into drill tailings both resulted in 3.2 x 10^{-9} LCF for CH-TRU waste exposures and 3.4 x 10^{-7} LCF for RH-TRU waste exposures. Detailed results of this analysis for Case 19 are presented in Table H-43.

Impacts of Borehole Intrusion into Pressurized Brine Reservoir

The extent of radionuclide and hazardous metals (predominately lead) migration under disturbed conditions at 10,000 years after closure for Case 19 (using the 75th percentile parameters) would be very similar to the results simulated for Case 4 (shown in Figure H-10). At 10,000 years, migration within the borehole and into the surrounding salt beds would extend upward approximately 20 meters (66 feet) above the repository. Migration would also extend downward in the borehole and the surrounding rocks to the Castile Formation and into the brine reservoir. As in the Proposed Action and Action Alternative 1, this migration would occur after the initial pressure in the brine pocket dissipates and the pressures in the repository and the overlying units penetrated by the borehole equilibrate over the 10,000-year simulation period.

Table H-43
External Dose (rem) for the Well-Site Geologist for a Drilling Intrusion Occurring at 100 Years Post-Closure for Action Alternative 3

CH-TRU Waste		RH-TRU Waste	
Radionuclide	**External Dose**	**Radionuclide**	**External Dose**
Am-241	4.1E-6	Sr-90	4.7E-4
U-234	9.6E-7	Cs-137	2.0E-4
Sr-90	7.5E-7	Am-241	1.7E-6
Cs-137	2.7E-7	U-234	7.9E-7
Pu-238	5.9E-8	Eu-152	1.5E-7
Pu-239	5.2E-8	Th-231	1.5E-7
U-233	4.5E-8	Y-90	6.8E-8
Th-228	1.7E-8	Pu-239	1.4E-8
Rn-222	1.3E-8	Cm-243	1.1E-8
Pa-233	9.5E-9	U-233	1.0E-8
Pu-240	9.4E-9	Th-234	6.7E-9
Th-234	9.1E-9	Pu-240	5.8E-0
Total (rem)	6.3E-6	Total (rem)	6.7E-4
Total (LCF)	3.2E-9	Total (LCF)	3.4E-7

H.8 ALTERNATIVE CONCEPTUAL MODELS AND VIEWS OF DISPOSAL PERFORMANCE

Several qualified and respected organizations and individuals, including members and contractors of the EPA, the Environmental Evaluation Group, the Office of the Attorney General of New Mexico, the WIPP Panel of the National Academy of Sciences, and others have participated in critical review of major WIPP compliance documents that are an important part of the compliance process. Key compliance documents include the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), the *Compliance Status Report for the Waste Isolation Pilot Plant* (DOE 1994), and the DCCA (DOE 1995a). These document reviews have given rise to a number of alternative conceptual models and views regarding WIPP disposal system performance that are relevant to this analysis. This discussion is included here to present other viewpoints of WIPP PA and to discuss how SEIS-II analyses consider them in its calculations.

Most of the review comments pertain to the PA process and scenario screening and selection. Primary concerns appear to lie with characteristics and processes of the Culebra Dolomite Member of the Rustler Formation and the Culebra's role in radionuclide transport and WIPP performance under certain human-intrusion scenarios. Less has been said about modeling of the Salado Formation salt and the repository. In light of the existence of natural resources and the region's hydrocarbon extraction and potash-mining history, the probabilities of human intrusion used in calculations have been questioned as well, and several additional scenarios have been suggested for analysis. This section provides a summary of most of the major findings and conclusions presented by these past reviewers. The review comments are organized into two categories: (1) WIPP characteristics and conceptual models and (2) human impacts and intrusion.

H.8.1 WIPP Characteristics and Conceptual Models

This section presents an overview of alternative opinions regarding currently used WIPP site characteristics data, conceptual models, and calculation methods put forth by scientific and engineering review organizations. This overview is organized into the following major subject areas: repository characteristics, Salado Formation, Rustler/Salado Contact, Rustler Formation/Culebra Dolomite Member, and units above the Rustler Formation.

H.8.1.1 Repository Characteristics

Radionuclide Mobility - Partitioning of Actinides Into Oxidation States

Generic actinide solubilities are used in the DCCA (DOE 1995a) calculations (i.e., solubilities of actinides of the same oxidation state are assumed to be equal). Actinides with multiple oxidation states are partitioned according to a set of simple formulae. According to Neill et al. (1996), this partitioning approach forces an actinide species to exist at several simultaneous oxidation states in certain proportions, which is not supported by experimental evidence. Also, a large uncertainty was associated with the assumed distribution of aqueous solubilities.

The Department has planned all along that experimentally determined actinide solubilities from its Actinide Solubility Program would be incorporated into calculations as they became available. Now, solubility values for several actinides have been experimentally determined and are being incorporated into WIPP PA calculations. The SEIS-II analyses have incorporated the new actinide solubility values in source-term release calculations.

Radionuclide Mobility - Colloids

In the DCCA (DOE 1995a), Neill et al. (1996) point out that colloids are thought to travel no faster than the noncolloidal dissolved contaminants. This assumption arbitrarily negates the concern about colloids and allows calculations of unconservative (i.e., lower-than-expected) transport rates. Therefore, initial colloid concentration is assumed instead of being measured or calculated.

Currently, WIPP PA methods and codes incorporate the concentrations of colloidal radionuclides into source-term release calculations. DOE has recognized the issues related to radionuclides in colloid form. In the DCCA, Section 6.4.5.4 (DOE 1996b), the following discussion is presented: "Colloidal activities are subject to retardation by interaction between colloids and solid surfaces and by clogging of small pore throats (that is, sieving). It is expected that there would be some interaction of colloids with solid surfaces in the anhydrite interbeds. Because of the low permeability of intact interbeds, it is expected that pore apertures are small and some sieving will occur. However, colloidal particles, if not retarded, are transported more rapidly than the average velocity of the bulk liquid flow. Because the effects on transport of increased average pore velocity and retarding interactions with solid surfaces and sieving are offsetting, the DOE assumes residual effects of these opposing processes will be either small or beneficial and does not incorporate them in modeling of the transport of actinides in the Salado interbeds." Similarly, SEIS-II analyses include calculated colloid concentrations and do not include consideration of colloid transport processes.

Radionuclide Transport Within Repository

The assumed location(s) of the intrusion borehole(s) penetrating a Castile Formation brine reservoir within the repository would affect calculated release rates of radionuclides from the repository (EPA 1995a). The effect of multiple intrusions on flow and transport was analyzed in the E1E2 scenario in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), but radionuclide transport within the repository and the effect on release rates were not modeled.

The EPA (1995a) evaluated the sensitivity of radionuclide release rates to borehole locations for several different geometries. The results of the analysis varied widely with both the number and the locations of the boreholes. In one case, most of the brine flowed quickly up the borehole leaving the radionuclides far behind. Four boreholes located at the corners of the repository enabled greater quantities of radionuclides to flow up the borehole. Ten uniformly arranged boreholes maximize the flow rate and quantity of radionuclides from the repository.

Radionuclide transport within the repository is not being explicitly modeled in the DCCA (DOE 1995a). Therefore, although it is recognized that multiple-borehole intrusion scenarios will yield higher releases than those resulting from a single-borehole intrusion, the intrusion scenario analyzed for the SEIS-II considers a single borehole by which to compare the Proposed Action with the alternatives.

Isothermal Calculations With BRAGFLO

Neill et al. (1996) state that BRAGFLO, according to the description and application presented in the DCCA (DOE 1995a), is "apparently an isothermal code," and that the justification for isothermal treatment of two-phase flow should be given. Neill et al. (1996) also feel that an assessment of errors introduced by this sort of approximation should be provided.

In the SEIS-II analyses, isothermal conditions were assumed for all simulations. With the thermal power limits imposed by planning-basis WAC, it is not anticipated that thermal loading from TRU waste will be an important factor in source-term release and near-field transport from the repository. The small amount of heat that will be generated by RH-TRU waste will be dissipated by the repository salt.

H.8.1.2 Salado Formation

Salado Halite and Interbed Parameters

The permeability of halite, as modeled in BRAGFLO, is that of "impure" halite and was determined through testing. Neill et al. (1996), in their review of the DCCA (DOE 1995a), maintained that it should be demonstrated that halite permeability bounds the overall permeability when interbeds, such as polyhalite and anhydrite, in the halite are considered. In addition, the effects of increased permeability of anhydrite interbeds from elevated gas pressures on the overall impure halite permeability should be incorporated.

Similarly, Neill et al. (1996) stated that if halite specific storage is used for the halite model, it should be demonstrated that the contribution of the interbeds to specific storage can be ignored. (The specific storage of a rock unit is a hydrologic term referring to the amount of water which would be squeezed from the unit's pores if the unit were compressed, as during creep closure, or

the amount of water which the unit's pores would absorb if the unit were dilated, as may occur with elevated gas pressure in the repository. An anhydrite interbed would likely have a specific storage that is different from that of an impure halite layer, particularly when dilation of fractures in the interbeds due to elevated gas pressure is considered.)

In the April 30, 1996, draft of the *Final No-Migration Variance Petition*, Section 8.0 (DOE 1996c), which employs median and other appropriate values (not sampled parameter distributions), it is stated that parameter values for impure halite used in the modeling are "supported by four hydraulic tests in the underground repository [and are] believed to represent far-field conditions and stratigraphic variation in the Salado." Further, "except for the DRZ and anhydrite interbeds, under certain circumstances, this simulation [involving fluid flow, gas generation, and volume changes resulting from creep closure] assumes spatially constant properties for Salado rock types based on observations of compositional and structural regularity in layers exposed by the repository. The inference is that there is little variation in large-scale averages of rock or flow properties across the disposal system. Except for anhydrite interbeds, model parameters are also spatially invariant within each material region. At relatively low repository pressures, porosities of all Salado materials vary slightly; however, for interbeds, the model implemented to simulate the effects of interbed fracturing causes large increases in both porosity and permeability above a designated fracture initiation pressure."

Regarding changes in interbed permeability and specific storage due to elevated gas pressures, it is stated in the April 30, 1996 draft of the *Final No-Migration Variance Petition* (DOE 1996c) that, "if high pressure develops in an interbed, its preexisting fractures may dilate, or new fractures may form, altering its porosity and permeability. Pressure-dependent changes in permeability are supported by experiments conducted in the underground repository and in the laboratory. Accordingly, the DOE has implemented in BRAGFLO a porous-media model of interbed dilation and fracturing that causes the porosity and permeability of a computational cell in an interbed to increase as its pore pressure rises above a designated value. There is a trade-off between the effects of permeability and porosity enhancements. Dilation or fracturing of interbeds is expected to increase the transmissivity of interbed intervals. Increased porosity will increase storage, which will retard outward flow." However, because of assumptions incorporated into the calculations, large increases in permeability are accompanied by modest increases in porosity. These concerns are accounted for in the PA calculations.

In SEIS-II analyses, values of Salado Formation halite and interbed parameters were derived from DOE databases supporting the DCCA (DOE 1995a) and *Draft No-Migration Variance Petition* (DOE 1995b). The analyses use both expected and conservative values based on existing distributions of these parameters.

Brine Inflow

The Environmental Evaluation Group (EEG) (1994), in its review of the *Compliance Status Report for the Waste Isolation Pilot Plant* (DOE 1994), states that the "project position" on the preferred conceptual model for brine inflow should be "developed and justified." Furthermore, "the EEG does not agree with the strategy of treating various conceptual models to be of equal importance when overwhelming evidence exists that a particular model is far superior than others." The EEG's recommendation is to assume Darcy flow in the salt, impure salt permeabilities, and fractured anhydrite, using measured in situ permeabilities in the marker beds.

The conceptual model for brine inflow, as described in Howarth et al. (1995), includes two submodels by agreement of WIPP Principal Investigators, far-field flow and redistribution mechanisms. (A previously proposed mechanism, clay consolidation, was not considered important and was not included). A 1-degree stratigraphic dip was added to the model, Darcy flow was assumed, and permeability for impure halite was used. Permeability for anhydrite (presumably intact) was based on field and laboratory measurements, and the chosen maximum fractured anhydrite permeability values were "thought to be upper limits" (Howarth et al. 1995).

This approach is used in the DCCA (DOE 1995a) and *Draft No-Migration Variance Petition* (DOE 1995b) and was adopted for the SEIS-II analyses. For the conservative case, the anhydrite permeability range included values for fractured anhydrite.

H.8.1.3 Rustler/Salado Contact

According to Neill et al. (1996), the contact zone between the Rustler and Salado Formations is characterized by residue left from dissolution of salt and has not been adequately considered as a potential pathway for migration of radionuclides. Several facts suggest that the Rustler/Salado contact merits further study. Chaturvedi and Channell (1985; cited in Neill et al. 1996) indicate that data from hydrologic testing at the WIPP site "shows that the 'brine aquifer' of the pre-WIPP investigators [*cf.* Robinson and Lang 1938] extends east of Nash Draw to the WIPP site." Most boreholes have encountered brine in the Rustler/Salado contact zone, and water-level-recovery rates were more rapid in these wells than in a well in the Culebra Dolomite east of the WIPP site, suggesting that the contact zone exhibits relatively high permeability and transmissivity.

In DOE's responses to EPA comments (DOE 1996d), it is stated that dissolution at the top of the Salado is not expected to reach the edge of the controlled area within the regulatory period of analysis of 10,000 years. The Rustler/Salado contact was not explicitly considered as a region of enhanced flow in the SEIS-II analyses.

H.8.1.4 Rustler Formation/Culebra Dolomite Member

Discussion of alternative conceptual models and issues related to the Culebra Dolomite are presented below in three parts: (1) regional flow, (2) hydraulic properties and characteristics, and (3) contaminant transport and retardation characteristics.

Regional Flow

Two-Dimensional versus Three-Dimensional Flow

The *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) treated flow in the Rustler Formation as occurring primarily in the Culebra Dolomite, which has been modeled as a confined, nonleaky, two-dimensional, horizontal, and heterogeneous water-bearing unit. It is, however, actually part of a three-dimensional flow system. SNL has been modeling three-dimensional flow in the Rustler and interim results indicate that, while some flow occurs vertically between units of the Rustler, most flow occurs within the Culebra. Therefore, confining flow to the Culebra in the PA calculations is a justifiable simplification. Konikow (1995) believes that the PA effort has been "overly focused" on the two-dimensional analysis and that the ongoing three-dimensional analyses of the regional groundwater flow system are critical to the PA effort.

Currently, DOE is retaining the concept of confined two-dimensional flow in the Culebra for compliance analysis. DOE is considering the development of a three-dimensional model for possible use in future PA calculations, to evaluate the impact of regional groundwater flow on long-term WIPP performance. Because no releases to the Culebra Dolomite were predicted in the SEIS-II analyses, the three-dimensional flow model of the Culebra was not used.

Regional Flow and Anomalous Groundwater Geochemistry

It has long been recognized that the chemistry of the Culebra groundwater is inconsistent with the apparent direction of flow. Based on hydrologic well data, groundwater in the Culebra flows roughly from north to south. Groundwater chemistry along the flow direction is not what would be predicted, based on common flow-chemistry relationships. Total dissolved solids decrease downgradient, and the general chemical nature of the water changes as well (sodium and chloride at the WIPP site to magnesium, calcium, and sulfate south of the site).

According to Neill et al. (1996) and Konikow (1995), this inconsistency reflects an inadequate level of understanding of the entire hydrogeologic system. Axness et al. (1995) state that "the relationship between water chemistry and groundwater flow in the Culebra remains unresolved at this time."

In Neill et al. (1996), the EEG advocates a "full discussion [in the DCCA] with respect to flow directions, vertical seepage, karst, present day recharge and paleo-recharge." The basis for determining the estimated age of Culebra groundwater as presented in the DCCA (i.e., "tens of thousands of years") and as "a relict of a flow regime of a wetter climate" (Neill et al. 1996), has never been accepted by Neill et al. (1996). According to the EEG, the arguments against the use of isotopic data from Carlsbad Caverns pools for Rustler groundwater (Neill et al. 1996) should be presented.

There are thorough discussions on vertical flow at WIPP in Axness et al. (1995), although there is little site-specific information presented on karst processes, present day recharge, and paleo-recharge. Arguments for both "young" and "old" Culebra groundwater are presented in Axness et al. (1995) and Galson et al. (1995), but there is no resolution of the issue in either reference and the two issues of Culebra groundwater chemistry and groundwater age remain open.

For the purpose of SEIS-II analyses, existing models are being used. DOE recognizes and acknowledges the issues and concerns (*cf.* Axness et al. 1995, and Galson et al. 1995).

Recharge/Discharge

In Neill et al. (1996), the EEG points out that the recharge area for the Rustler has never been identified. At least two areas have been proposed on the basis of potentiometric surfaces, but "existing data are inadequate to determine recharge to the groundwater system in the vicinity of the WIPP site."

It is accepted that the Culebra probably discharges ultimately into the Pecos River and, perhaps, elsewhere (Neill et al. 1996). However, hydraulically separate water-bearing zones cannot be distinguished within the Rustler Formation at least 3 kilometers (2 miles) east of Livingston Ridge; therefore, water flowing into postulated areas of discharge may not be traced to a particular member of the Rustler Formation (Neill et al. 1996).

For the purpose of SEIS-II analyses, existing models are being used. DOE recognizes and acknowledges the issues and concerns (*cf.* Axness et al. 1995, and Galson et al. 1995).

Unexplained Recent Changes in Water Levels

Neill et al. (1996) believe that the observed water-level rises in the Culebra are notable, in that they may be related to hydrocarbon and potash activity in the area. The DCCA (DOE 1995a) used data through 1991 only in its related discussion, although there have been data collected up to the present. Konikow (1995) believes that the observations are important and maintains that the lack of a satisfactory interpretation is another element in the generally inadequate understanding of the site hydrogeology.

According to Neill et al. (1996), "water level rises in WIPP monitoring wells potentially correlate with brine disposal from the potash industry." Further, "in 1988, WIPP monitoring wells experienced sharp water level rises which were strongly correlated with a nearby salt water disposal well operated by the oil and gas industry." These instances emphasize that WIPP is located in a resource-rich area, exploration and exploitation of the resources are likely to continue, and activities related to this may influence the regional hydrology apart from the modeled scenarios involving penetration of the repository. Therefore, Neill et al. (1996) maintain that more emphasis must be placed on interpreting the changes in Culebra water levels.

It is mentioned in Galson et al. (1995) that unexplained water-level rises in the Culebra may be the result of a leaking saltwater disposal well, and it is stated that "activities involving fluid injection in the Delaware Basin are unlikely to have a detrimental effect on the performance of the waste disposal system, unless there is fluid leakage to units overlying the repository through a failed borehole casing." It is stated further that leakage from boreholes, as the result of fluid injection and the effects on groundwater flow, "are retained for evaluation."

The DOE (1996d), in its responses to comments from the EPA, notes that injection of fluids in strata other than the Salado will not affect the WIPP repository.

Hydraulic Properties and Characteristics

Independent Sampling of Parameters

In the probabilistic PA calculations, many parameters are sampled. It has been pointed out (*cf.* EEG 1994; Konikow 1995; Neill et al. 1996) that certain model parameters in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* are being treated as independent random variables. This is a weakness (Konikow 1995) because, in reality, the variability of some sets of parameters indicates dependence on one another. For example, the values for fracture porosity and fracture spacing used in some flow and transport modeling calculations were sampled randomly from a selected range. This approach implies that there is no dependency between these two parameters. Single fractures could have very small apertures (resulting in low porosity) and multiple closely spaced fractures could have very large apertures (resulting in high porosity). These assumptions result in very large ranges in fracture hydraulic conductivity, which runs contrary to most hydrologists' understanding that fracture spacing and fracture aperture (porosity) generally increase or decrease together.

The EPA (1995a) evaluated the relationship between and among fracture spacing, fracture porosity, and hydraulic conductivity. Based on the range of fracture spacings used in the

Preliminary Performance Assessment for the Waste Isolation Pilot Plant (SNL 1992), the EPA calculations indicated that corresponding fracture porosities are much lower than those used in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992). The PA calculations, therefore, indicate higher flow and transport rates and are very conservative.

In the SEIS-II analyses, expected and conservative parameter values (corresponding to 50th and 75th percentile, respectively) were used, rather than sampled values.

Fracture Properties

According to the EEG (1994), statements in the *Compliance Status Report for the Waste Isolation Pilot Plant* (DOE 1994) regarding areal distribution and density of fractures in the Culebra are simplistic and ignore existing data, that the "pattern of fracture distribution and corresponding transmissivity values distribution is too complex to be explained away," and that its complexity has become more apparent as additional data are collected. In response, DOE stated that deduced fracture patterns were based on many observations in drill core, as well as outcrops and exposures in the air intake shaft.

Konikow (1995) states that fractures are a dominant control on transmissivity and they represent the highest-velocity channels for migration of contaminants. Further, a better definition of the nature, density, spacing, length, and interconnectedness of fractures and fracture networks is needed. He characterizes this uncertainty regarding Culebra fractures as "the most likely fatal flaw in site integrity."

Accordingly, Konikow (1995) believes that, given the fact that detailed local and regional mapping of fracture traces and lineaments were not completed during the early stages of site characterization, new approaches should be taken that may help clarify the possible existence and spacing of major through-going fracture zones. He indicates that techniques that could accomplish this include computer analysis of digital elevation data and high-resolution three-dimensional geophysical tomographic techniques. This issue remains open.

The EEG (1994) states that more than one conceptual model of the Culebra appears to fit the available data. Other possible interpretations include single-porosity flow (flow through the rock matrix), dual-porosity flow (flow through fractures in the rock, as well as the rock matrix), and channeling (flow through certain fractures only). Of equal importance is the role of matrix diffusion as a retardation process (diffusion of radionuclides through the fracture faces into the rock matrix; see below).

The EEG (1994) points out that the INTRAVAL committee (International Project to Study Validation of Geosphere Transport Models) believes that, while the current model incorporates dual-porosity flow, a model based entirely on channeling also fits the current field data. The channeling model does not incorporate matrix diffusion.

For compliance calculations and the purposes of SEIS-II, DOE is incorporating the assumption that flow in the Culebra is confined to a single fracture "in order not to overestimate the amount of diffusion [of radionuclides]" (Axness et al. 1995). Diffusion of radionuclides into fracture walls has the effect of slowing their transport and, thus, increasing retardation. Limiting the Culebra to a single fracture minimizes retardation and is a more conservative approach. In addition, in recognition of the importance of fracture characteristics of the Culebra, the DOE has conducted

multiple-well tests and tracer tests to evaluate these characteristics and their influence on the regional groundwater flow field.

Karst Development

Anderson (1994), in his review of the *Compliance Status Report for the Waste Isolation Pilot Plant* (DOE 1994), disagreed that the absence of visible karstic surface features at WIPP implies that important karst processes are not occurring. According to Anderson, the "moderate thickness of halite and gypsum strata in the Rustler Formation precludes the development of large, visible collapse structures until late stages of dissolution." Sand cover at WIPP would tend to obscure smaller-scale features.

Anderson (1994) presents evidence that dissolution from karst processes is active at WIPP: (1) a dissolution front beginning along the Nash Draw axis has moved eastward approximately 16 kilometers (10 miles) to its present position within the WIPP site; (2) this dissolution front has moved in pulses in response to changes in climate; and (3) the northward extension, or finger, of the southeastern lobe of Nash Draw in the southern part of the WIPP site coincides with the main flow path in the Rustler aquifer and with the known localized area of increased transmissivity (Beauheim and Holt 1990; Anderson 1994).

Anderson (1994) cites several lines of evidence that suggest that karst processes at WIPP are at a relatively early stage: (1) the age of Nash Draw has been determined to be less than 600,000 years, which is considerably younger than has been believed (Beauheim and Holt 1990, cited in Anderson 1994); (2) the high-transmissivity zone is characterized by relatively fresh groundwater that is unsaturated with respect to gypsum, and by fractures from which gypsum has been dissolved; (3) fractures in soluble units below the Culebra, visible in one of the WIPP shafts, have been enlarged by dissolution to form flow channels; (4) hydraulic conductivity across the site varies by a factor of one million (specific Rustler lithologic units were not specified); and (5) vertical movements of fluids between units in the Rustler are characteristic.

It is stated in Axness et al. (1995) and Galson et al. (1995) that climate change is the principal natural process that could affect flow and transport above the Salado Formation from changes in infiltration of moisture and recharge to hydrologic systems. Galson et al. (1995) relate this to the potential development of karst features, but no site-specific discussion of karst development at WIPP is presented.

The DOE does not specifically address the karst issue in the long-term performance assessment. However, for the SEIS-II, a potash mining scenario was analyzed which incorporated a three-order-of-magnitude increase in the hydraulic conductivities (which control permeabilities) in overlying hydrologic units. This analysis allowed the investigation of the potential effects of increased permeability from any cause, including karst development.

Contaminant Transport and Retardation Characteristics

Equilibrium Sorption

During transport of contaminants, several chemical processes may serve to slow down (i.e., retard) the contaminants. These processes include precipitation of the contaminants in a chemical compound, ion-exchange processes, or adsorption onto solid surfaces. These processes are collectively referred to as retardation. They may be temporary, as precipitation may stop in

response to chemical conditions, or the solid surfaces may fill up with sorbed contaminants and lose their capacity to sorb further. For many contaminants, groundwater compositions, and rock/soil types, it is possible to estimate by calculation the distribution of contaminants sorbed on the rock and dissolved in the water by determining the distribution coefficient.

Distribution coefficients have been measured for application to WIPP but they do not represent anticipated conditions in the Culebra (Neill et al. 1996) for the following reasons: (1) experiments have used water that was chemically different from Culebra water; (2) the distribution coefficients were determined from single measurements on powdered samples, which have much greater surface area compared to their volume than the actual fractured Culebra rock and, therefore, would tend to show an artificially high degree of sorption; and (3) it was not well demonstrated that equilibrium was achieved in the experiments.

According to Konikow (1995), the use of a single retardation factor, as in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* calculations (SNL 1992), has a "very weak scientific basis" because it cannot represent the sources of variation in the PA model (chemical reactions, reaction rates, heterogeneous mineralogy, and changing aqueous geochemistry). In addition, Konikow (1995) states that the retardation factor model used does not place an upper limit on the amount of contaminant that can be sorbed. This means that the model does not account for the possibility of sorption sites filling up and precluding further sorption. He further states that sorbing tracer tests in the field are needed.

A multiwell tracer test is currently being conducted at the WIPP site and is designed to ascertain, among other things, distribution coefficients for sorbing contaminants but using a nonsorbing tracer. Neill et al. (1996) compared residence times for sorbing and nonsorbing species in a system of porous and fractured rock. Their simple analysis indicates that a nonsorbing tracer test cannot be used to obtain a distribution coefficient for sorbing contaminants such as the radionuclides at WIPP.

Currently, clay linings in Culebra fractures are assumed not to be present (Axness et al. 1995). It is anticipated that, in the final compliance certification application, clay fracture linings will be assumed and credit will be taken for some degree of chemical retardation (DOE 1996c).

In the SEIS-II analyses, no transport calculations in the Culebra were performed since no contaminant releases to the Culebra from disturbed conditions were predicted.

Repository and Culebra not Coupled in Modeling

In the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), the quantities of radionuclides calculated to leave the repository and flow up an intrusion borehole were incorporated into the simulation of flow and transport in the Culebra, but they were not introduced hydraulically into the flow regime of the Culebra (i.e., the influence of water flowing up the borehole on the ambient flow field of the Culebra was not calculated). Expressed another way, the processes in the repository were decoupled from processes in the Culebra.

The EPA (1995a) evaluated the effect on transport times of coupling repository and Culebra processes. It was found that travel times to the WIPP boundary decreased (i.e., transport rates increased) by approximately ten times (one order of magnitude). Similarly, radionuclide concentrations calculated at one kilometer (0.6 mile) from the repository after 10,000 years were approximately ten times higher in the coupled-process calculations.

The SEIS-II analyses follow the approach taken in the *Draft No-Migration Variance Petition* (DOE 1995b) and the DCCA (DOE 1995a), in which impacts of the borehole intrusion on the Culebra flow field are not considered. Reeves et al. (1991) performed a study that indicated that, for expected conditions and much of the range of brine reservoir and breach borehole parameters, the fluid disturbance created in the Culebra by the breach borehole would have minimal impact on the flow field. It was further stated that, under these conditions, transport calculations need not include the transient impact of locally increased hydraulic head near the breach borehole.

In the intrusion scenario analyzed in SEIS-II, the borehole was designed to reflect current oil field practices. It was assumed that the intrusion borehole is plugged and thereafter maintains a relatively low permeability. In the scenario, the borehole penetrates the entire sequence of units in the modeled domain. The borehole permeability was initially set to 1×10^{10} square meters (1×10^{11} square feet) to represent a relatively high borehole permeability for 100 years after the intrusion. After 200 years, the borehole permeability was decreased to 1×10^{-14} square meters (1×10^{-13} square feet) to reflect a decrease in permeability consistent with plugging the borehole with concrete. For these assumed conditions, no releases to the Culebra Dolomite were simulated.

Realism of Calculated Travel Times

In the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), the Culebra was modeled by using various transmissivity fields, each of which was divided into regions of different hydraulic conductivity. For the purpose of travel time calculations, however, a mean Culebra hydraulic conductivity of 7 meters (23 feet) per year was used.

The EPA (1995a) compared travel times calculated by using the mean, as in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), with those calculated by using the separate regions of hydraulic conductivity. Their results suggest that using separate hydraulic conductivities yields travel times "far shorter" (less conservative) than using the mean hydraulic conductivity for the entire Culebra.

In the SEIS-II analyses, no transport calculations in the Culebra were performed since no contaminant releases to the Culebra from disturbed conditions were predicted.

Parallel Fracture Model Analysis for Culebra

Neill et al. (1996) state that the basis for the parallel fracture model in the SECO analyses for the Culebra in the DCCA (DOE 1995a) is not presented nor is the justification for clay linings on the fracture walls, and that the influence of this assumption on the outcome of the calculations should be described. Channeling of groundwater flow should be considered, because it is recognized as a possibly important phenomenon in the Culebra.

In PA calculations for compliance, a single fracture in the Culebra was assumed to limit the amount of fracture surface and calculated matrix diffusion. Porosity was assumed to be the approximate median of the distribution sampled in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), and tortuosity was given a "medium low" value (Axness et al. 1995). The fracture is assumed to be devoid of clay lining, and the distribution coefficient is taken to be zero (Axness et al. 1995).

In the SEIS-II analyses, no transport calculations in the Culebra were performed since no contaminant releases to the Culebra from disturbed conditions were predicted.

Presence/Absence of Clay in Fractures

Neill et al. (1996) believe that there is insufficient evidence of clay linings in Culebra Dolomite fractures to assume their presence for purposes of estimation of retardation of radionuclide transport. The assumption of corrensite as the predominant clay mineral present in the fractures is also based on limited data.

According to the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* calculations (SNL 1992), chemical sorption on clay fracture linings is assumed to occur and the clay mineral present is assumed to be corrensite. Neill et al. (1996) provide a discussion of the evidence on which these assumptions are based. SNL has been assuming in their PA calculations that fractures in the Culebra are lined to some degree with clay and that the clay has been determined to be corrensite. The presence of corrensite is based on X-ray diffraction and electron microscopic analysis of core samples taken from clay-rich zones in the Rustler Formation (not necessarily in the Culebra Member), primarily from locations in Nash Draw, several miles west of the WIPP site. Results of the studies have been presented in several SAND reports.

In a study by Sewards et al. (1991; cited in EEG 1994 and Neill et al. 1996), X-ray diffraction determination of corrensite was not corroborated by the electron microscopy, yet they concluded that corrensite is the dominant clay phase in the Culebra (EEG 1994). Also, in Sewards et al. (1994; cited in EEG 1994 and Neill et al. 1996), it was stated that only small amounts of clay could be sampled from the Culebra fracture coatings. As a result, initial laboratory studies of adsorption on WIPP site clays were carried out with material from a black shale layer from the unnamed member of the Rustler Formation. The material was determined from a single sample to be mostly corrensite. Neill et al. (1996) state, in summary, that using a single sample from a shale located in a different part of the Rustler from the Culebra is not appropriate for PA calculations that depend on the presence of sufficient corrensite clay in Culebra fractures to effect notable retardation of radionuclides. Therefore, either more evidence is needed for radionuclide sorption on clay linings or credit should not be taken for chemical retardation in fractures.

Clay can be a medium for sorption but it can also block radionuclides from diffusing into the rock matrix (see discussion below on physical retardation). The *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) did not include the latter concept in its calculations (Neill et al. 1996). If the clay is not an effective sorber, it serves to inhibit migration of radionuclides into the matrix, thereby increasing the efficiency of channel flow.

For the purpose of PA calculations (Axness et al. 1995), clay linings in Culebra fractures are assumed not to be present. It is anticipated that in the final compliance certification application, clay fracture linings will be assumed and credit taken for some degree of chemical retardation (DOE 1996a).

In the SEIS-II analyses, no transport calculations in the Culebra were performed since no contaminant releases to the Culebra from disturbed conditions were predicted.

Physical Retardation (Matrix Diffusion)

PA calculations (SNL 1992) suggest that radionuclides will take from 100 to 1,000 years to travel from the repository to the WIPP boundary. This indicates that without matrix diffusion to slow up (retard) the radionuclides, cumulative releases would be greater over the 10,000-year regulatory period. It is believed by some (Neill et al. 1996; Konikow 1995) that there is insufficient evidence

to assume that matrix diffusion plays an important role in retarding radionuclides in the Culebra. It is Konikow's (1995) opinion that field tests performed to date are ambiguous, that diffusion parameters have not been adequately characterized in laboratory tests, and that the nature of the fractures in the Culebra are not known sufficiently well to formulate a representative model.

Neill et al. (1996) state that, though PA takes credit for matrix diffusion, there is "no direct experimental evidence for its extent." The EEG (1994) points out that the INTRAVAL committee believes that existing field data support a channeling flow model (i.e., without matrix diffusion) as well as the dual-porosity model. The EPA (1995a) performed simple calculations of travel times and distances with and without the retarding effects of matrix diffusion to obtain comparisons. For a set of simplifying conditions (fracture spacing 3.85 meters [12.6 feet], equivalent porous media hydraulic conductivity 7 meters [23 feet] per year, no chemical retardation), the calculation of distance traveled in 10,000 years yielded the following results: (1) with matrix diffusion, radionuclides traveled approximately 5 kilometers (3 miles) and (2) with no matrix diffusion, radionuclides traveled approximately 13,500 kilometers (8,383 miles), or 2,700 times farther.

In an attempt to limit the amount of fracture surface and ensure that matrix diffusion calculations are conservative, it was assumed by Axness et al. (1995) that fracturing in the Culebra is limited to one horizontal fracture. Fracture porosity was taken to be approximately the median of the range sampled in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992), and tortuosity was given a "medium low value" (Axness et al. 1995).

In the SEIS-II analyses, no transport calculations in the Culebra were performed since no contaminant releases to the Culebra from disturbed conditions were predicted.

H.8.1.5 Supra-Rustler Units

The water table in the region of the WIPP has not been defined. Konikow (1995) states that, in part, this reflects the degree of understanding of the site hydrology. He recommends that it either should be defined of a reasonable explanation regarding why it is not important or not technically feasible to define should be documented.

According to Neill et al. (1996), "without an understanding of the basic regional hydrologic parameters of an area, such as the water table and the recharge and discharge areas and amounts, the knowledge about the site is incomplete." They state that it is believed that the water table is in the Dewey Lake Formation, based on observations of water in several wells and one of the repository shafts at the WIPP site. Wells in the Dewey Lake have produced water at rates up to 106 liters (28 gallons) per minute (Neill et al. 1996; Axness et al., 1995).

In the *Final No-Migration Variance Petition* (DOE 1996c) simulation of the WIPP disposal system pressure gradient, it was assumed that the water table is located approximately 59 meters (194 feet) below the ground surface at an elevation of 980 meters (3,215 feet) within the Dewey Lake Formation. The Dewey Lake Formation contains a "productive zone of saturation, probably under water-table conditions" (Axness et al. 1995) in the southwestern and south-central portion of the WIPP site as well as south of the site. This zone occurs approximately in the middle of the Dewey Lake and appears to derive much of its transmissivity from open fractures (Axness et al. 1995). North of the site, open fractures and/or moist (not saturated) conditions have been observed in the Dewey Lake at similar depths. Fractures below the productive zone tend to be filled with gypsum.

The role of the Dewey Lake Formation in repository performance is an issue as yet unresolved. Because the Culebra is assumed to be the principal pathway for contaminant transport above the Salado in the event of a repository breach as a result of human intrusion, the SEIS-II analyses do not specifically address off-site contaminant transport in the Dewey Lake.

H.8.2 Issues Related to Human Impacts and Intrusion

Scenarios analyzed in the *Preliminary Performance Assessment for the Waste Isolation Pilot Plant* (SNL 1992) and assumptions regarding deterrents to human intrusion have come under review, and several scenarios not yet analyzed have been proposed. This section presents discussions on an analyzed scenario and the application of institutional controls.

Presence/Absence of Borehole Casing in Intrusion Borehole

Neill et al. (1996) identified an apparent inconsistency in intrusion scenarios analyzed to date. One set of scenarios, in which contaminated brine from the repository flows up the borehole and through the Culebra, implies that there is no casing in the vicinity of the Culebra. Another scenario analyzes the effect of CUTTINGS_S generated during drilling and brought to the land surface, bypassing the Culebra. This implies, according to Butcher et al. (1995; cited in Neill et al. 1996), that a well casing is present. Current drilling technology in the Delaware Basin calls for steel casing from the surface to within 100 to 200 meters (330-660 feet) of the "top of the salt section" (Butcher et al. 1995; cited in Neill et al. 1996).

According to Neill et al. (1996), two different scenarios should be analyzed: one with casing and the other without, with assignment of probabilities of occurrence to each. This issue was not directly addressed in SEIS-II. In the intrusion scenario analyzed in SEIS-II, the borehole was designed to reflect current oil field practices. No explicit credit is taken for the presence of casing. It was assumed that the intrusion borehole is plugged and thereafter maintains a relatively low permeability. In the scenario, the borehole penetrates the entire sequence of units in the modeled domain. The borehole permeability was set initially to 1×10^{10} square meters (1×10^{11} square feet) to represent a relatively high borehole permeability for 100 years after the intrusion. After 200 years, the borehole permeability was decreased to 1×10^{-14} square meters (1×10^{-13} square feet) to reflect a decrease in permeability consistent with plugging the borehole with concrete.

Credit for Passive Institutional Controls

Passive institutional controls (PICs) were considered to be a sufficiently effective deterrent to human intrusion in the DCCA (DOE 1995a), to the extent that the possibility of human intrusion was not included in the cumulative complementary distribution function. Neill et al. (1996) believe that no credit should be taken in the Complementary Cumulative Distribution Function for a reduced future (beyond 100 years) drilling frequency based on PICs. The SEIS-II intrusion scenario was analyzed at 100 years after closure.

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APPENDIX I

APPENDIX I
LONG-TERM CONSEQUENCE ANALYSIS FOR NO ACTION ALTERNATIVE 2

I.1 INTRODUCTION

This appendix provides detailed information related to the consequence analysis for No Action Alternative 2, including background information on the scenarios analyzed, descriptions of the conceptual models of releases used, and data input parameters cited. Also provided are the specific analytical methods, computer codes, and exposure calculations used. Methods described include summaries of models and codes used for waste source-term release, contaminant transport, radiation dose, and chemical exposures. The report also provides a summary of human health impacts for the sites considered in the analysis.

I.1.1 Background

Long-term environmental consequence analyses were not performed for the no action alternatives in either the *Final Environmental Impact Statement for the Waste Isolation Pilot Plant* (FEIS) (DOE 1980) or the *Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant* (SEIS-I) (DOE 1990). The impact analyses described in those documents focused on expected site operations associated with treatment and storage, with the assumptions that transuranic (TRU) waste would be indefinitely stored at 10 major generator sites and that institutional control would be sufficient to preclude any site impacts. In general, it is estimated that if effective monitoring and maintenance of storage facilities were provided, adverse health effects to the general public would be quite small, and the principal adverse effects, also small, would be related to occupational activity at the facility. Health effects would continue indefinitely at such levels under the hypothesis of the U.S. Department of Energy (DOE or the Department) control.

However, if the DOE were to lose institutional control of the storage facilities, it is estimated that intruders could receive substantial radiation doses, a situation that could persist for the indefinite future. In addition, contaminants in TRU wastes stored in shallow burial trenches and surface storage facilities will eventually be released and would persist in the surrounding environments at the generator-storage sites, exposing on-site and off-site populations to chronic health risks.

In the FEIS and SEIS-I analyses, DOE referenced completed National Environmental Policy Act documents for some of the major retrievable storage facilities to describe the effects of continued retrievable storage. These sites included the Hanford Site (Hanford), Idaho National Engineering Laboratory (INEL), and the Savannah River Site (SRS) (DOE 1987; 1980; and 1988, respectively).

The Record of Decision on the FEIS, which was published on January 28, 1981, determined, as part of the basis for decision, that the No Action Alternative was "unacceptable." This determination was made at the time because of the potential impacts of natural, low-probability events and human intrusion at storage facilities after governmental control of the site is lost. In SEIS-I (DOE 1990), a summary of the FEIS analysis was provided and the conclusion was again reached in the Record of Decision, published in June 21, 1990, that the No Action Alternative was unacceptable.

I.1.2 Purpose and Scope

In this *Waste Isolation Pilot Plant Disposal Phase Draft Supplemental Environmental Impact Statement* (SEIS-II), No Action Alternative 1 assumes that DOE would indefinitely maintain institutional control and, therefore, long-term impacts of post-closure intruders and environmental release were not assessed. No Action Alternative 2 assumes that TRU waste would not be emplaced at Waste Isolation Pilot Plant (WIPP) during the disposal phase, and, therefore, no radiological consequences to workers or the public would be realized in and around WIPP in this case. However, exposures would continue to occur at the major treatment facilities.

Under No Action Alternative 2, TRU waste is generated at all sites, including small-quantity sites, over the next 35 years. During this period, waste generated at the small-quantity sites would be consolidated and treated at the 10 major treatment sites, as described for this alternative in Chapter 3. Both consolidated and generated TRU waste will be put into retrievable storage consistent with current practices. Current storage configurations include soil-covered asphalt or concrete pads, shallow trenches, earthen berms, covered enclosures, storage buildings for contact-handled (CH) TRU waste, and buried caissons for remote-handled (RH) TRU waste. TRU waste would remain in these assumed storage configurations for an institutional control period of 100 years, beginning in 2033. During this period of institutional control, effective monitoring, surveillance, and maintenance would be expected to minimize the risk of contaminant release from the storage configurations.

At the end of the 100 years, following a TRU waste-generation period (i.e., 2133), institutional control is assumed to be lost. As facilities begin to degrade, TRU waste would be introduced into the accessible environment.

Calculations of the long-term consequences resulting from environmental releases from the storage facilities were performed for a 10,000-year period after the loss of institutional control. Environmental and human health impacts as a result of storage-facility releases were not evaluated for the period of institutional control.

Because 99 percent of the estimated TRU waste volume and inventory that would be generated can be accounted for at seven of the 10 major treatment sites (see Appendix A), environmental and human health impacts were estimated at these seven sites only: Hanford, INEL, Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), Rocky Flats Environmental Technology Site (RFETS), and SRS. The three remaining sites not considered for this analysis were Argonne National Laboratory, the Mound Plant, and Nevada Test Site.

To the extent possible, this long-term consequence analysis for No Action Alternative 2 uses environmental data sets and models developed for low-level waste and low-level mixed waste consequence analyses conducted in the *Draft Waste Management Programmatic Environmental Impact Statement* (Draft WM PEIS) (DOE 1995b). The data sets and models were modified for assumed TRU waste inventories, storage site locations, and related environmental transport parameters, as appropriate. Data sources for this analysis include site descriptions and data provided in the following:

- Draft WM PEIS (DOE 1995b)
- referenced contractor reports supporting the Draft WM PEIS analysis (Holdren et al. 1995, Bergenback et al. 1995, and Blaylock et al. 1995)
- key site-specific environmental references
- *Transuranic Waste Baseline Inventory Report, Revision 2* (BIR-2) (DOE 1995d)

I.2 RISK ANALYSIS METHODOLOGY

The human health impacts of TRU waste were estimated for two types of exposures: (1) inadvertent human intrusion into areas of TRU waste storage and (2) source-term releases to surface and subsurface environmental exposure points.

Consistent risk measures were used to facilitate the comparison with the disposal alternatives. For radioactive substances, doses were estimated for the maximally exposed individual (MEI) and exposed populations for a 70-year lifetime period of highest dose and then expressed in terms of latent cancer fatalities (LCFs). For hazardous carcinogens, excess cancer incidence was calculated to the MEI and to the exposed population for a 70-year lifetime of highest exposure. For noncarcinogenic substances, the hazard index for the MEI for the highest period of exposure was estimated.

The following section provides the approaches used for the inadvertent human intrusion and the long-term environmental releases used in this analysis.

I.2.1 Inadvertent Human Intrusion Impacts

Estimation of impacts from inadvertent human intrusion considered the following scenarios in this analysis.

- In this scenario, a hypothetical intruder drills a well directly through buried or soil-covered TRU waste to underlying groundwater. As a result of the drilling, contaminated soil is brought to the surface and mixes with the topsoil. The intruder is exposed via inhalation of resuspended contamination, external radiation, and inadvertent ingestion of contaminated soil. Exposure occurs to the driller while at the site over a 5-day period (one work week). The contamination is assumed to be instantaneously mixed into the top 15 centimeters (6 inches) of clean surface soil. Further, it was assumed that the extent of contamination was limited to an area of 10 meters by 10 meters (33 feet by 33 feet).

- In this scenario, the same individual farms a garden on the land containing the contaminated soil (following the driller intrusion) over a period of 30 years. During this time, the intruder will receive 25 percent of the yearly vegetable and fruit intake from this garden. The area of contamination is limited to that of the drill cuttings, assumed to be 100 square meters (1,090 square feet). In addition to food crops, the individual is further exposed via inhalation of resuspended contamination, external radiation, and inadvertent ingestion of contaminated soil. The gardener was assumed to spend 12 hours a day working outside and, thus, is exposed to the soil 4,383 hours per year. The gardener's inhalation exposure is 8,766 hours per year (at 24 hours per day) and the soil ingestion rate is 100 milligrams (3.5×10^{-3} ounces) per day for 365.25 days per year. Also, the gardener

ingests 14 kilograms (30.8 pounds) per year of leafy vegetables, 55 kilograms (121 pounds) per year of root vegetables, 31 kilograms (68 pounds) per year of fruit, and 73 kilograms (161 pounds) per year of grain, all assumed to have grown in the contaminated region of his yard.

- In this scenario, a hypothetical scavenger intruder comes into direct contact with surface-stored TRU waste over a 24-hour period. The scavenger is exposed via inhalation of resuspended contamination, external radiation, and inadvertent ingestion of contaminated soil while at the site. The scavenger does not ingest any food but is exposed via inhalation of resuspended soil (waste) and via external radiation. It is also assumed that no clean soil covers the waste, so the dose factors per unit concentration are multiplied by the waste form concentration to get the total dose to the scavenger.

- In this scenario, a hypothetical farm family of two adults and two children lives and farms on the land immediately over the former surface-stored TRU waste disposal area. The MEI in the family is exposed via ingestion of contaminated food crops, inhalation of resuspended contamination, external radiation, and inadvertent ingestion of contaminated soil.

To assess the dose and risk from these human intrusions, a unit methodology was employed. To bound the impact, it was assumed that all intrusions occur at the moment institutional control is lost (i.e., 2133). For each location, unit concentrations of contaminants in soil were modeled using the GENII computer code (see Appendix F). Contaminant concentrations were then multiplied by the anticipated concentration of relocated waste in the top 15 centimeters (6 inches) of soil. Doses from all of the radionuclides of concern were summed to yield the total effective dose equivalent for each receptor. Calculated doses were then converted to appropriate LCFs using methods described in Appendix F.

The GENII calculations assumed that the driller intruder was exposed via external ground radiation for 40 hours, via inhalation of resuspended soil for 1 hour, and via inadvertent ingestion of soil for 5 days at a rate of 100 milligrams (3.5×10^{-3} ounces) per day. The soil resuspension is based on an average mass loading factor of 1.0×10^{-4} gram of soil per cubic meter (6.3×10^{-9} pounds per cubic feet) of air. From these input parameters, a dose factor of dose per curie per cubic meter of soil down to 15 centimeters (6 inches) was derived.

Calculation of the contaminant concentration was based on the initial waste form concentration multiplied by the volume of waste relocated in the top 15 centimeters (6 inches) of soil in the 10-meter by 10-meter (33-foot by 33-foot) area. The circular drill hole was assumed to be 30 centimeters (12 inches) in diameter and 4 meters (13 feet) in depth. The volume of waste removed by drilling was then instantaneously combined with the clean soil in the top 15 centimeters (6 inches) of the soil column. This contaminant concentration multiplied by the dose per concentration values generated by GENII resulted in an overall dose to the driller intruder.

For the driller's hazardous chemical component, the air concentration was multiplied by the driller's breathing rate for a total intake. This intake was then compared to the slope factor for carcinogens and to the permissible exposure limits for noncarcinogens. These factors are summarized in Appendix F. To calculate the air concentration, the waste concentration was multiplied by the volume of the waste, then adjusted by the release fraction (assumed to be one in the driller intruder analysis). The release was then assumed to occur uniformly over the 10-meter by 10-meter (33-foot by 33-foot) area and was multiplied by the resuspension rate (the same as

above, 1.0 x 10^{-4} gram per cubic meter [6.3 x 10^{-9} pounds per cubic feet]). The driller's breathing rate was assumed to be 20 cubic meters (706 cubic feet) per day.

The gardener scenario following the driller scenario and the scavenger scenario employed the same methodologies for determining dose except that the exposure times were longer, the area of contamination was larger, and ingestion was included as a pathway. All factors employed for radiological dose and hazardous chemical exposures and associated risks are provided in Appendix F.

I.2.2 Long-Term Environmental Release Impacts

Estimation of impacts from long-term chronic environmental exposures considered the following exposure scenario receptors in this analysis.

- In this scenario, a hypothetical farm family of two adults and two children lives 300 meters (984 feet) downgradient based on average groundwater flow of a TRU waste storage area. The family grows and consumes their own crops and livestock and uses contaminated groundwater as a source of drinking water. Contaminated groundwater is also used for watering the crops and animals. This receptor was considered for long-term releases from buried or soil-covered TRU waste and surface-stored TRU waste.

- In this scenario, a hypothetical individual is exposed to the maximum airborne contaminant concentration released from the stored TRU waste release site. This receptor, located at least 100 meters (328 feet) from the release site but within an 80-kilometer (50-mile) radius, was only considered for long-term releases from surface-stored TRU waste.

- In this scenario, a hypothetical off-site population consumes contaminated surface water. Only drinking water was considered. Surface water is contaminated via atmospheric transport of contaminants and/or mixing with the groundwater pathway. This receptor was considered for long-term releases from both buried or soil-covered TRU wastes and surface-stored TRU waste.

To the extent possible, the Modular Risk Analysis (MRA) methodology used in the Draft WM PEIS (DOE 1995b) was used for this analysis. Evaluation of the multimedia transport of radionuclides and chemical contaminants in air, surface water, and groundwater pathways was done using the MEPAS® code. The source-term-release component of the MEPAS® code was used to generate a specified release rate for each assumed TRU waste form. This was done to simulate the release of radionuclides and hazardous chemicals from TRU waste from a storage facility. MEPAS® calculates the annual flux rate of each contaminant released from a storage facility. Output from the MEPAS® source-term-release module was used as input for the MEPAS® transport module calculations.

GENII was used to calculate the dose (in rem) per unit concentration in the waste for those radionuclides considered to be of concern (see Section I.6). The dose per unit concentration was multiplied by a site-specific radionuclide concentration to estimate the potential dose. Doses from all of the radionuclides of concern were summed to yield the total effective dose equivalent for each receptor. Doses were then converted to appropriate LCFs using methods described in Appendix F.

Output for the hazardous chemical concentrations calculated by the MEPAS® transport module was used by MEPAS® risk components to calculate a cancer incidence and hazard index profile of over 10,000 years for chronic releases of both carcinogenic and noncarcinogenic hazardous substances, respectively.

The MRA methodology was developed by Pacific Northwest National Laboratory and Advanced Sciences, Inc. to facilitate regional-scale risk analysis. This methodology is described in several documents (Strenge and Chamberlain 1995; Whelan et al. 1994a) and presentations (Whelan et al. 1994b). The MRA methodology was developed for regional- and site-wide risk computations involving a large number of release sites with different TRU waste forms for various environmental settings and transport and exposure pathways.

The MRA methodology is based on the assumptions of linearity between the release-site source, the environmental transport, and the impacts at the receptor. By assuming the linearity of the system, the methodology can be divided into compartments that can be implemented both independently and concurrently. The compartments of the MRA methodology are (1) contaminant mass at the source, (2) determination of contaminant release rate from the source, (3) transport modeling of the contaminant into the environment (environmental concentrations at the receptor location), (4) exposure assessment for dose to receptor (MEI or population), and (5) estimation of impacts at the receptor.

The MRA methodology is based on the following general description for health impact:

$$\text{Health Impact} = P \times RF \times URF \qquad \text{(Equation I-1)}$$

where Health Impact is the estimated probability of adverse effects (carcinogenic risk for radionuclides and chemical carcinogens, and hazard quotient for noncarcinogenic constituents) from a contaminant at a receptor; P is the probability of the release event (unitless); RF is the releasable fraction of the source (unitless); and URF is the health impact associated with a contaminant at a receptor based on a unit quantity at the source. URF expresses health impact (cancer incidence for radionuclides and chemical carcinogens, and hazard quotient for chemical noncarcinogens) and is determined as follows:

$$URF = [\,(Q \times UFF) \bullet UTF\,] \times UDF \times UIF \qquad \text{(Equation I-2)}$$

where Q is the estimated quantity of contaminant at the source in grams or curies; UFF is a time series of contaminant release rate fluxes designated as contaminant mass per time divided by unit contaminant mass; and UTF is a time series of environmental concentrations at a receptor produced from the UFF for groundwater, air, surface water, and soil media (expressed as contaminant mass per volume of medium divided by unit contaminant mass per time).

UDF is the dose to an organism from a unit concentration for a given exposure pathway. For chemicals, UDF is expressed as contaminant mass per body mass per time divided by unit contaminant mass per volume of contaminant in the environment at the receptor point. For radionuclides, UDF is expressed as contaminant total dose (rem) divided by unit contaminant mass per volume of contaminant in the environment at the receptor point.

UIF is the unit health impact factor that provides the dose conversion factor for radionuclides, cancer potency factor for chemical carcinogens, or reference dose for noncarcinogenic contaminants. For radionuclides, UIF is expressed as cancer fatalities divided by unit contaminant

total dose. For chemical carcinogens, UIF is expressed as cancer incidence divided by unit contaminant mass per body mass per time. For chemical noncarcinogens, UIF is expressed as hazard quotient divided by unit contaminant mass per body mass per time.

Whereas Equation I-2 provides a description of the link between the different unit factors involved in computing the URF, Equations I-3 through I-6 provide a description of each of the unit factors that were developed to compute URFs. Note that the UFF and UTF are time series that must be convoluted together. The source, UDF, and UIF are multipliers.

$$UFF = \frac{F_s}{S_u} \qquad \text{(Equation I-3)}$$

where S_u is the unit source mass (grams) or the unit source activity (curies) and F_s is the contaminant flux release rate from the TRU waste form expressed as mass per time. UFF includes the probability of release and the release factor fraction for a given scenario.

$$UTF = \frac{C_f}{F_u} \qquad \text{(Equation I-4)}$$

where F_u is the unit contaminant flux rate expressed as mass per time and C_f is the contaminant concentration at the receptor based on transport through the appropriate media expressed as mass per volume.

$$UDF = \frac{D_c}{C_u} \qquad \text{(Equation I-5)}$$

where C_u is the unit concentration at the receptor expressed as mass per volume and is based on contaminant transport through the appropriate media and D_c is the dose from the contaminant (for chemicals, D_c is expressed as mass of contaminant per body mass per time; for radionuclides, D_c is expressed as the total dose to a human receptor).

$$UIF = \frac{R_d}{D_u} \qquad \text{(Equation I-6)}$$

where D_u is the unit dose to a human (for chemicals, D_u is expressed as mass of contaminant per body mass per time; for radionuclides, D_u is expressed as total dose). R_d is the health impact associated with a unit dose (for chemical carcinogens, R_d is expressed as cancer incidence divided by mass of contaminant per body mass per time; for chemical noncarcinogens, R_d is expressed as hazard quotient divided by mass of contaminant per body mass per time; and for radionuclides, R_d is expressed as cancer fatalities divided by total dose).

Average environmental conditions that are dependent on the TRU waste storage site were selected. Separate URFs and associated factors were developed for the different environmental settings of the seven major generator sites. Environmental settings were assumed to have homogeneous climatological, hydrologic, and geologic characteristics. Therefore, the URF is representative of the risk from a release site within a region and not an actual risk. The local climatological, hydrologic, and geologic characteristics for this analysis were developed using the Draft WM PEIS in Holdren et al. (1995). The regional climatology (joint frequency distributions) and population for regional air receptors for the seven major generator sites were based on the Draft WM PEIS

methods described in detail in Bergenback et al. (1995). Details of the selection and application of these data and information for this analysis are described in Buck et al. (1996).

Conceptual site models were developed for each environmental setting associated with a storage site. These models defined the relationship between the source contaminant at the release sites and the health impacts at the receptors. The important components associated with these relationships were the constituents of interest, waste-source types, release mechanisms, exposure media, and receptor types. For this analysis, the probability of a release or exposure event was assumed to be 1.0. Likewise, it was assumed that sources were in a releasable form such that RF is equal to 1.0.

Once the waste configuration and TRU waste forms for each environmental setting were identified, the release mechanisms were identified. For this analysis, infiltration of contaminants to the vadose and groundwater system was considered to be the primary release mechanism. Volatilization, suspension, and overland flow release mechanisms were also considered. The resulting release rate (contaminant flux) for each release mechanism was also dependent on the TRU waste form. In addition, the solubility of each contaminant in the TRU waste form was an important factor in determining contaminant release rates. TRU waste forms listed in Appendix A were categorized to approximate the release of contaminants from the waste form into the environmental media. It was determined that all waste forms fell into one of two bounding waste form types, soil or cement. An analysis of the solubility limits for the primary TRU waste contaminants at each site was conducted. The results were incorporated into the computations of contaminant fluxes.

UFFs were generated using the MEPAS® model to simulate the release of contaminants from a source term. The model directly considers contaminated soil and solidified (cement) TRU waste forms. Contaminant is removed from the source by simultaneously evaluating degradation or decay, groundwater leaching, atmospheric volatilization, and soil erosion by wind suspension and overland runoff, as appropriate. To verify that contaminant release rates were not higher than the potential solubility associated with the TRU waste forms analyzed, Q (the estimated quantity of contaminant at the source) was included with the UFF to produce total flux factors. These were subsequently convoluted with the UTFs, thereby eliminating the contaminant release versus waste form solubility issue.

The UTF represented the environmental fate and transport component of the unit factor methodology. The UTF value was based on 1 gram or 1 curie of contaminant at the source which, after being transported through a specific environmental medium, ultimately arrives at the receptor exposure point. The receptor exposure point for groundwater analysis was a well 300 meters (984 feet) directly downgradient from the source, assumed centerline of the plume. The atmospheric receptor was located at the point of highest concentration that is at least 100 meters (328 feet) and within a radius of 80 kilometers (50 miles) from the release point. The UTF is media dependent. For example, UTF for air is expressed as milligrams per cubic meter per gram, or picocuries per cubic meter per curie; as milligrams per square meter per gram, or picocuries per square meter per curie for soil; and as grams per milliliter per gram, or curies per milliliter per curie for surface water and groundwater.

The UDF involves an average daily intake in milligrams per kilogram per day for chemicals or a lifetime radiation dose in rem for radionuclides. UIF relates the chemical intake or radiation dose to a risk or hazard index, as appropriate, for each pollutant. Both UIF and UDF are defined for intake or exposure routes of inhalation, ingestion, and external radiation.

Three different human health impact types were estimated, including exposure to carcinogenic radionuclides, carcinogenic chemicals, and noncarcinogenic chemicals. These impacts are directly related to the three types of UIFs computed for this analysis.

MEI receptors influence UDF calculations by defining dose intake factors and UTF calculations by defining the exact location of the receptor; as a result, MEI impacts were calculated and then used in the determination of population impacts. The combination of the UDF and UTF requires the convolution of time series and straight multiplication. The UFF and UTF are time series at different locations. The UFF is the time series of contaminant release rate from the source, while the UTF is the time series of contaminant concentration at the receptor point. The UTF and UDF require the convolution of time series and those products can combine with the UDF by straight multiplication. Equation I-7 provides the convolution method used to combine the series (the convolution operation is represented by the symbol •).

$$URF = [Q \times UFF] \bullet UTF(\tau) = \int_0^{\tau} [Q \times UFF(t)] \bullet UTF(\tau - t)dt \qquad \text{(Equation I-7)}$$

Once the convolution is completed, all the factors can be combined (based on Equation I-2) to provide health risk or hazard quotient impact values.

I.3 COMPUTER CODES

The potential health impacts from exposure to radioactive material and hazardous, nonradioactive material releases were evaluated with two computer codes. The MEPAS® code (described in Droppo et al. 1989 and 1991; Whelan et al. 1987; Strenge and Peterson 1989; and Buck et al. 1995) was used to assess contaminant transport and to calculate toxicological impacts and carcinogenic risks from hazardous constituents. GENII, described in Napier et al. (1988a, 1988b, 1988c), was used to calculate radiation dose from atmospheric releases and from radioactive material contamination trapped in soil. A brief discussion of the key components of the MEPAS® and GENII codes used in this analysis is presented in this section.

I.3.1 MEPAS® Code

The MEPAS® code integrates and evaluates transport and exposure pathways for chemicals and radioactive releases according to their potential human health impacts. MEPAS® is a physics-based approach that couples contaminant release, migration, and fate for environmental media with exposure routes and health consequences for radiological and nonradiological carcinogens and noncarcinogens.

Contaminant release from the waste zone was modeled with the source-term release component of MEPAS®. In general, the mass or activity of a contaminant in the source zone decreases over time because of contaminant removal by first-order degradation or radioactive decay, leaching to the groundwater, wind suspension, surface water erosion, and volatilization.

Radioactive and hazardous waterborne and hazardous airborne contaminant transport in multiple media were calculated using the transport components of the MEPAS® code. The MEPAS® waterborne transport code consists of: (1) groundwater, (2) surface water, and (3) overland transport models. These three transport models can either be run separately or linked to provide environmental concentrations at specified receptor points. For each waterborne transport pathway,

contaminant retardation is described by an equilibrium coefficient, k_d. First-order degradation or decay is assumed for all contaminants that do not result in toxic decay products. For radionuclides in the waterborne transport pathway, parent contaminants are conservatively treated (i.e., not decayed) during transport through intermediate pathways. On reaching the environmental receptor point, radiological decay is corrected using the Bateman equation, and the code subsequently computes the temporal distribution of each decay progeny.

The MEPAS® atmospheric transport code considers the input of suspension and volatilization release rates to compute transport and dilution, washout by cloud droplets and precipitation, and deposition on the underlying surface cover. The atmospheric model uses climatological information on wind speed and direction, precipitation, and atmospheric stability (joint frequency distribution data) to compute average air and surface contamination concentrations. The atmospheric model also accounts for plume depletion from decay and deposition to ensure mass balance for the system. Contaminant transport was assumed to occur quickly enough so that chemical transformation can be omitted.

Results from the different transport pathway models were used as input to the exposure to calculate the human health impacts for each hazardous chemical contaminant. The following exposure routes were considered to determine the potential exposure to the MEI and the surrounding population: (1) dermal contact, (2) external exposure, (3) inhalation, and (4) ingestion. Each exposure route is evaluated to obtain an estimated average daily human exposure from each contaminant. The daily exposure rates are then converted, using mathematical codes, to average individual impact factors for carcinogenic and noncarcinogenic chemicals. Detailed information on the exposure component of MEPAS® can be found in Appendix F.

I.3.2 GENII Code

Although GENII models the environmental transport, contaminant accumulation, and radiation dose to an individual or population, it was used to calculate doses only from radiological concentrations estimated by MEPAS®. GENII was used for acute (less than 24-hour) release, chronic release, or exposure scenarios. Methods for calculating doses with GENII are found in Appendix F.

I.4 WASTE CHARACTERISTICS

To model the health effects associated with TRU waste at the various DOE sites, the waste must be characterized in terms of its volume, contaminant inventory, and waste form. The site-specific volumes and contaminant inventories used for No Action Alternative 2 are discussed in Appendix A. The following discussion presents descriptions of TRU waste forms and waste form categories, the quantity of each waste-form category, and the contaminant inventory distribution of each TRU waste-form category used in this analysis.

I.4.1 Description of TRU Waste Forms and TRU Waste-Form Categories

TRU waste form characteristics can have large effects on the rate at which contaminants are released from the waste zone. TRU waste-form characteristics vary widely at the treatment sites but can be classified into one of two general waste-form categories. These waste-form categories and the modeling parameters associated with each are discussed below.

The first general waste-form category is comprised of unconsolidated TRU wastes. Because this waste is unconsolidated, it is assumed to be permeable. Thus, water percolating through a zone containing this category of waste would come into contact with all surfaces of the waste once waste contours are breached. This type of waste zone is also susceptible to wind suspension and water erosion processes. The release of contamination by leaching is regulated by the relative tendency of contaminants to exist in an aqueous phase or sorbed to solid surfaces. This partitioning between the aqueous and adsorbed phases is often expressed in terms of a surface-adsorption coefficient, k_d, and is dependent on the contaminant and the solid adsorbent material. If a contaminant is present in high-enough concentrations, the capacities of the aqueous and sorbed phases to contain the contaminant can be exceeded. Contaminant release, therefore, will be controlled by its solubility.

Unconsolidated TRU waste types in this first waste-form category can be further subdivided into those having either low or high surface-area-to-volume ratios. Examples of TRU waste with low surface-area-to-volume ratios and relatively low surface adsorption coefficients include waste containers, personal protective equipment (PPE), and metal process equipment. Contaminants from this type of TRU waste readily leach into the surrounding soil. Their release from the waste zone is controlled by the sorptive properties of the surrounding soil.

Unconsolidated TRU waste with high surface-area-to-volume ratios can have high surface adsorption coefficients. Contaminant release from these TRU waste types may be controlled by the sorptive properties of the TRU waste form itself. Examples of high surface area wastes include sludge, soil, and spent filters/adsorbents. Although the TRU waste form may control the release rate, physical data available for these waste types are limited, making it difficult to estimate sorption coefficients. For these types of TRU waste it is conservatively assumed, therefore, that the sorptive properties of the surrounding soil can also be used to determine the release characteristics of the high surface area TRU waste forms.

The second general waste-form category is comprised of solidified TRU waste whose permeability is much lower than that of the surrounding soil while sufficiently high to allow contaminant mobility within the TRU waste form. Percolating water tends to move around this category of waste and leach contaminants only from their exterior surface. The most common example of this TRU waste form is cemented waste. As contaminants are removed from the exterior surface, concentration gradients are established and contaminants tend to diffuse from the interior of the waste to the exterior surface. Therefore, the contaminant leaching release rate depends on the internal mobility of the contaminant, which is often expressed as an effective contaminant diffusion coefficient. Wind suspension and water erosion are assumed not to affect this solidified waste-form category until the TRU waste form fails.

In addition to contaminant-specific grout diffusion coefficients (Buck et al. 1996), the surface-area-to-volume ratio of the TRU waste form is required to model the release of contamination. It was assumed that waste will be disposed of in 55-gallon drums approximately 91 centimeters (36 inches) tall and 66 centimeters (26 inches) in diameter and that a cement slurry is poured directly into the drum, completely filling it. Using these assumptions, a surface-area-to-volume ratio of 0.082 cm^{-1} was calculated.

Another important parameter required for modeling contaminant release from this TRU waste-form category is the effective lifetime of the waste form. Cement degrades over time and will crack into small pieces such that the release of contamination is no longer limited to surface diffusion. At this point, contaminant release will be controlled more by surface adsorption and desorption than by diffusion. The effective lifetime of the TRU waste form depends on various properties of the

cement, including the type of solidification agent used, solidification agent-to-waste-to-water ratios, curing conditions, waste composition, and storage environment conditions, such as the number of wet/dry and freeze/thaw cycles. An effective lifetime of 500 years was used for cemented TRU waste forms in this analysis.

I.4.2 Quantity of Each TRU Waste-Form Category

The relative quantities of each TRU waste-form category at a site were determined using information available in Appendix A and BIR-2 (DOE 1995d). BIR-2 specifies a waste volume and waste density for each of 10 waste material types (Table I-1). These waste material types were categorized into one of the general TRU waste-form categories modeled in this analysis.

The total mass of each TRU waste material type at each site was calculated by summing the product of the waste volume and the waste density for each waste stream. The total mass of all TRU waste material was used to determine the weight percent of each type of waste material at the various sites.

CH-TRU and RH-TRU waste masses for the different waste material types within a general category were combined to determine the relative weight percent for each general TRU waste-form category. Because of the lack of supporting data, the densities of the cement and soil TRU waste forms were assumed equal. In this way, weight percent analysis could be applied directly to the total waste volume. This assumption has minor impact on the resulting information.

Under No Action Alternative 2, TRU waste would be located in the 200-East and 200-West areas at Hanford. Because the distribution between the two Hanford areas is not currently known, it was assumed that 50 percent of the total volume would be disposed of at each Hanford location. The final relative percentages for each general TRU waste-form category at each release site are shown in Table I-2. These relative quantities were multiplied by the total TRU waste volumes for the site (see Appendix A) to determine final site volumes for each TRU waste-form category. Volumes are also reported in Table I-2.

I.4.3 Contaminant Inventory Distribution of Each TRU Waste-Form Category

The radioactive and hazardous contaminant inventories used in the No Action Alternative 2 analysis, as discussed in Appendix A, are the total inventories present at each site for CH-TRU and RH-TRU waste. The inventories were not broken down by TRU waste material type. For the purpose of this analysis, the CH-TRU and RH-TRU waste inventories are added together and assumed to be distributed over the different TRU waste-form categories with the same relative ratios as the volume fractions. For example, if a site has 75 percent soil/debris and 25 percent cement TRU waste volume, the contaminant inventory was distributed 75 percent to soil/debris and 25 percent to cement.

I.5 WASTE CONFIGURATION AND CONTAMINANT RELEASE SCENARIOS

This section describes the basis for the source-term release analysis, which provided the contaminant flux factors in the MRA methodology described in Section I.2.2. Topics of this section include a general conceptual site storage model for buried or soil-covered TRU waste and surface-stored TRU waste, and assumptions governing the release of contaminants from the TRU waste-form categories.

Table I-1
Categorization of BIR-2 TRU Waste Materials into General Waste-Form Categories[a]

TRU Waste Material Type	General TRU Waste-Form Category
Iron-based Metals/Alloys	Soil/Debris
Aluminum-Based Metal/Alloys	Soil/Debris
Other Metals	Soil/Debris
Other Inorganic Materials	Soil/Debris
Cellulosics	Soil/Debris
Rubber	Soil/Debris
Plastics	Soil/Debris
Solidified, Inorganic Matrix	Cement
Solidified, Organic Matrix	Cement
Soils	Soil/Debris

[a] BIR-2 (DOE 1995d)

Table I-2
Relative Quantities and Volumes of Each TRU Waste-Form Category by Release Site

Release Site	Relative Quantities (percent)		Volumes (cubic meters)	
	Soil/Debris	Cement	Soil/Debris	Cement
Hanford Site - 200 East Area	100.0	0.0	43,500	0
Hanford Site - 200 West Area	100.0	0.0	43,500	0
Idaho National Engineering Laboratory	84.3	15.7	26,200	4,890
Lawrence Livermore National Laboratory	97.4	2.6	1,160	31
Los Alamos National Laboratory	63.8	36.2	13,600	7,700
Oak Ridge National Laboratory	76.1	23.9	4,200	1,320
Rocky Flats Environmental Technology Site	77.6	22.4	8,340	2,430
Savannah River Site	85.2	14.8	10,300	1,790

The overall geometrical configuration of a waste storage zone, the assumed degradation of the waste storage zone, and the distribution of the TRU waste forms within the zone affect the magnitude and areal extent of the contaminant release fluxes from the zone. Each is discussed in this section.

I.5.1 Waste Storage Configuration

The following assumptions were made for the analysis of the buried or soil-covered TRU waste: (1) all TRU waste is contained in 55-gallon drums 91 centimeters (36 inches) tall and 66 centimeters (26 inches) in diameter that are stored together in one shallow burial zone, (2) four layers of drums are stacked on an asphalt or concrete pad with plywood sheets between the layers

and on top, and (3) 1.2 meters (4 feet) of contaminant-free soil is used as backfill over the layers of drums. This overall configuration is illustrated in Figure I-1.

For the analysis of surface-stored TRU waste, the initial waste zone configuration is similar to that for buried or soil-covered TRU waste. It is assumed that four layers of drums are stacked on an asphalt or concrete pad with plywood sheets between the layers and on top as illustrated in Figure I-2. However, instead of being placed in a buried or soil-covered configuration, the stacked drums are placed in metal storage buildings or covered storage areas.

The relative amount of material in a surface storage configuration versus a buried storage configuration was determined for each site using the following assumptions. First, the waste that is currently stored in either a surface configuration or buried waste configuration is not moved to a different configuration. Second, newly generated wastes are placed in a surface storage configuration. The relative amounts of waste in each configuration are shown in Table I-3.

The vertical dimension of the waste zone for buried, soil-covered, and surface-stored configurations is approximately equal to 3.7 meters (12 feet). The drums are placed as close to one another as is possible in a rectangular grid arrangement. Because of this configuration, the volume of the waste zone will be larger than the volume of the TRU waste itself. The ratio of waste zone and waste drum volumes for a rectangular grid arrangement is:

$$\left[\frac{n \times (2r)^2 \times (4h)}{n\pi r^2 \times (4h)}\right] = \frac{4}{\pi} \qquad \text{(Equation I-8)}$$

where n is the number of drums, r is the drum radius, and h is the drum height. Waste zone volumes for each TRU waste-form category are calculated for each site by multiplying the corresponding volumes reported in Table I-2 by $4/\pi$. These overall waste zone volumes are reported in Table I-3. The horizontal cross-sectional areas of each TRU waste-form category for each site can be calculated by dividing the waste zone volumes by 3.7 meters (12 feet). These areas are also reported in Table I-3.

I.5.1.1 Facility and Waste Degradation

The ability of storage buildings, waste configuration components, waste containers, and TRU waste forms to contain contaminants needs to be considered when modeling the long-term release of contaminants. The following discussion provides an overview of each of these considerations in terms of their effect on the long-term release of contaminants from TRU wastes.

Facility Degradation

The surface storage scenario assumes that TRU waste is housed in metal storage buildings or a covered storage area. These buildings or covers will degrade relatively quickly as compared to the 10,000-year evaluation period, due chiefly to the lack of maintenance after the loss of institutional control. Therefore, metal storage buildings, enclosures, and covers are assumed to offer no protection and the surface storage scenario is modeled as if the stacked waste drums were not sheltered for the entire evaluation period. Facility degradation is not applicable to the buried or soil-covered TRU waste.

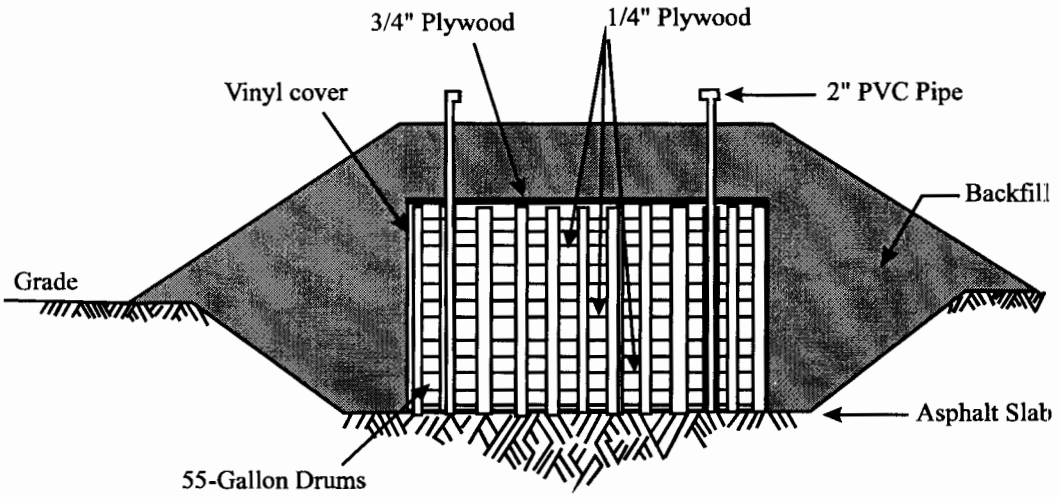

Figure I-1
Buried or Soil-Covered TRU Waste Storage Zone Configuration

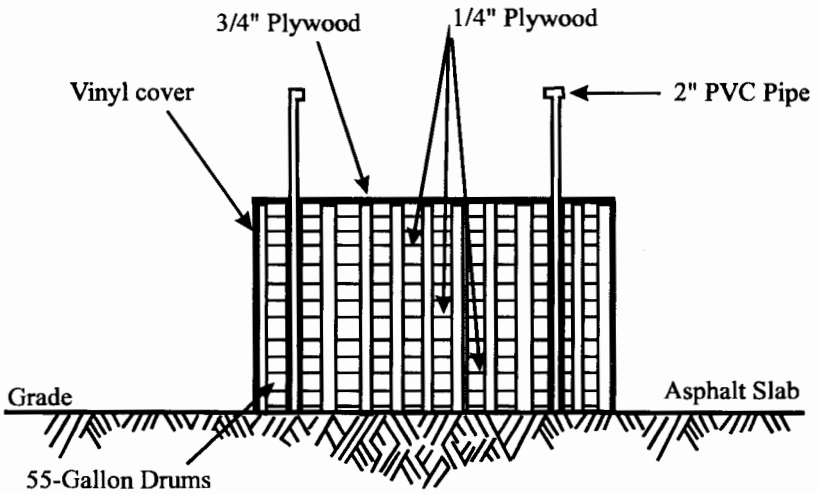

Figure I-2
Surface TRU Waste Storage Zone Configuration

Table I-3
Waste Zone Volumes, Horizontal Areas, and Configurations for Each Waste-Form Category By Release Site

Release Site	Waste Zone Volumes (cubic meters)		Waste Zone Horizontal Areas (square meters)		Waste Zone Configuration (Percent)	
	Soil/Debris	Cement	Soil/Debris	Cement	Buried	Surface
Hanford 200 East	55,300	0	15,200	0	13.6	86.4
Hanford 200 West	55,300	0	15,200	0	13.6	86.4
INEL	33,400	6,230	9,150	1,710	49.9	50.1
LANL	17,300	9,800	4,740	2,690	37.9	62.1
LLNL	1,480	40	406	11	0	100
ORNL	5,350	1,680	1,470	460	15.2	84.8
RFETS	10,700	3,090	2,940	848	0	100
SRS	13,091	2,280	3,590	624	11.6	88.4

Waste Configuration Degradation

Components of the TRU waste form configuration are assumed to degrade quickly relative to the 10,000-year evaluation period. Degradation of the plywood or the storage building allows the spaces between the drums to fill with soil from the surface layer of the site. Likewise, once storage buildings degrade, the drums themselves will degrade at an accelerated rate, further altering the waste configuration.

It is also assumed that any asphalt or concrete pad at the base of the waste storage zone will be cracked or otherwise degraded for essentially the entire 10,000-year evaluation period. This allows infiltrating water to percolate through the waste zone, pass through the cracked or degraded pad, and move through the remainder of the vadose zone directly beneath the waste zone.

Waste Container Degradation

The integrity and longevity of the waste drums is also a factor in contaminant release from the waste zone. Both the surface-stored and buried or soil-covered scenarios assume that TRU waste will be contained in mild steel, U.S. Department of Transportation (DOT)-17C 55-gallon drums. Corrosion rates for mild steel drums are quite high even when buried in favorable, dry environments (i.e., drum lives of less than 100 years are expected). For surface storage facilities, once the storage enclosure or building degrades to the point where waste drums are directly exposed to the elements, stored TRU waste drums are expected to degrade more rapidly than TRU waste drums in a buried or soil-covered configuration. Because the expected life of the waste drums is relatively short compared to the 10,000-year evaluation period, no credit was given for the presence of containers during the evaluation period in the analysis.

Cemented TRU Waste Form Degradation

Initially, the cemented TRU waste form is assumed to be a solid block having the same size and shape as a 55-gallon drum. Cemented monoliths are known to crack and degrade into porous material over time. Unfortunately, the theory for modeling the transition from a solid block to

porous material and its effect on contaminant release is not well developed. It is assumed, therefore, that the cemented waste blocks remain intact for the first 500 years and then catastrophically fail. After failure, the waste zone is assumed to act as a porous material.

I.5.1.2 Distribution of TRU Waste Forms

The horizontal cross-sectional area of the source zone is a required modeling input parameter. In reality, all drums of a given TRU waste-form category will not be emplaced in a single location within the waste zone. Rather, they will be interspersed with drums containing other TRU waste-form categories. To simplify the analysis, however, it is assumed that any specific area location contains drums of only one TRU waste-form category over the four vertical layers. It is also assumed that the waste zone is composed of a random distribution of "reasonably large" subareas of drums of only one TRU waste-form category. Each subarea is of sufficient size so that contaminant release is controlled by the physics and chemistry of that subarea's TRU waste-form category alone. Therefore, contaminant release from the waste zone can be modeled in two parts (one for each waste-form category) using the conceptual mathematical models described and the appropriate fractional inventories and areas for each TRU waste-form category.

Contaminant mass flux is the output of source-term calculations for the subarea of each TRU waste-form category. Because the subareas are assumed to be uniformly dispersed throughout the waste zone, the mass flux of any contaminant from the two waste-form categories can be summed to determine the total mass flux of that contaminant over the cross-sectional area. Mass fluxes over the total waste zone area are required inputs for subsequent transport simulations.

I.5.2 Contaminant Release Scenarios

An overview of contaminant release scenarios from the different TRU waste forms for both the surface-stored and buried or soil-covered waste configurations is presented in this section. Geochemical controls that may limit the contaminant release from the overall waste zone are also discussed.

The overall rate of contaminant mass loss from the waste zone is the sum of the mass loss rates of five different loss processes. These processes are (1) decay, (2) leaching, (3) wind erosion, (4) water erosion, and (5) volatilization. The buried or soil-covered-waste scenario under No Action Alternative 2 assumes a 1.2-meter (4-foot) cover layer of soil that considerably reduces TRU waste interaction with surface erosion/dispersion mechanisms. By assuming that contaminant release to these mechanisms is zero, the contaminant inventories available for leaching increase, providing a maximized scenario for groundwater contamination. Leaching and decay, therefore, are the only two loss processes considered for the buried or soil-covered waste scenario.

A "multimedia" scenario was used for surface-stored releases. Water erosion, wind suspension, and volatilization were considered in addition to leaching and decay. This scenario assumes that there is no cover layer and contaminant transport by water erosion and wind suspension begins at the start of the analysis. Thus, the surface-stored scenario maximizes the potential air exposures. The effects of different TRU waste forms on each of the release mechanisms are discussed below.

I.5.2.1 Soil/Debris TRU Waste Form

When the waste zone is comprised of a soil/debris waste form, all five loss processes can occur. Degradation or decay is assumed to be a first-order process. Leaching is either solubility- or

desorption-controlled. When there is no solubility-controlled solid phase, as with radionuclides and metals, or an organic liquid phase, as with organic chemicals, contaminant loss via leaching is assumed to occur by desorption-controlled transport. The velocity of the water percolating through the porous TRU waste form dominates this mode of transport. If the aqueous concentration of the contaminant is controlled by solubility, the mass flux is the product of the solubility of the contaminant and the volume of leachate passing through the waste zone. Water erosion and wind suspension are assumed to strip particles from the soil surface at a constant rate. These values were assumed to be zero for the buried or soil-covered waste scenarios to maximize leaching losses. Water erosion and wind suspension rates for the surface-stored scenario were calculated with MEPAS®.

Volatilization losses of organic contaminants were assumed to be zero in the buried or soil covered-waste scenario to establish a bounding case for groundwater contamination. In contrast, holes would develop in waste drums rather readily in the surface-stored scenario, causing most of the volatile organic inventory contaminants to be lost through volatilization. Therefore, the entire organic inventory is assumed to be released through volatilization during the first year, generating a maximized airborne scenario for volatile organic contaminants.

I.5.2.2 Cemented TRU Waste Form

The distribution of contaminants between different phases within the porous cement is not accounted for explicitly in the analysis. Decay and leaching are the only loss processes assumed to occur prior to failure. Decay of the overall contaminant mass is again assumed to be a first-order process. Infiltration water percolating through the waste zone is assumed to not penetrate the cemented TRU waste form. Rather, leaching loss results from percolating water flowing around the surface of the waste form and picking up contaminants as they diffuse through the water-filled pores of the cement. The cemented TRU waste form is assumed to fail after 500 years and, like the surface-stored scenario, it begins to act as a soil/debris TRU waste form and wind erosion, water erosion, and volatilization will begin.

I.5.3 Geochemical Controls on TRU Waste-Form Leaching

When the TRU waste form is cemented, leached contaminants do not immediately move out of the bottom of the waste zone. Under the assumed waste configuration, soil exists between each of the drum-shaped forms. Leached contaminants enter this soil zone before exiting the bottom of the waste zone with the percolating water. If the physical and chemical processes in this soil zone are such that contaminant leaching from the soil is slower than from the TRU waste form itself, this release process is the limiting step. The source-term release module, therefore, compares the leaching mass flux calculated from the cement TRU waste form with the leaching mass flux calculated under the assumption that the waste zone was composed of soil. The leaching mass flux used is the lower value of either the predicted desorption-controlled or the solubility-controlled soil release.

I.6 CONTAMINANTS OF CONCERN (CoC)

Initially, there were 141 radioactive, 47 organic, and 13 nonradioactive inorganic CoCs possible at the various treatment sites. To concentrate data collection efforts and analysis time on those CoCs that would contribute most to associated site hazards, a screening analysis was conducted. This analysis varied for radioactive, organic, and inorganic CoCs because of differing amounts of data available for each group. Data for the radioactive contaminants included site-specific radionuclide

inventories. The screening analysis for this group of contaminants was divided into two possible transport pathways of concern: (1) airborne and (2) waterborne. A schematic of the screening process is shown in Figure I-3.

I.6.1 Radioactive Contaminant Screening Analysis

The first transport pathway to be considered was airborne contamination. It was assumed that unit amounts of waste, soil, or debris, with radioactive contaminant concentrations proportional to their inventories, were suspended by wind and transported through the air to a receptor. The human health impact resulting from this transport is, therefore, a function of the contaminant's inventory and inhalation dose factor. The relative impacts for each contaminant were compared and ranked according to their contribution to human health impact. The radionuclides with a combined risk equal to 90 percent of the total relative risk were designated as the airborne radioactive CoCs (Table I-4).

Leaching through the vadose zone to the groundwater was the second transport pathway to be considered. Contaminants must be present in sufficient quantities to result in health impacts through this pathway. Also, the site must have the necessary climatological and surface soil characteristics to percolate the amount of water needed to leach the contaminant from the waste zone and transport it through the vadose zone. The contaminant must then transport through the aquifer to a groundwater well, where it must be present in high enough concentrations and with sufficient toxicity to present consequential health impacts. Finally, radioactive contaminants must have long enough half-lives to sustain notable quantities of contaminant during the time required for transport.

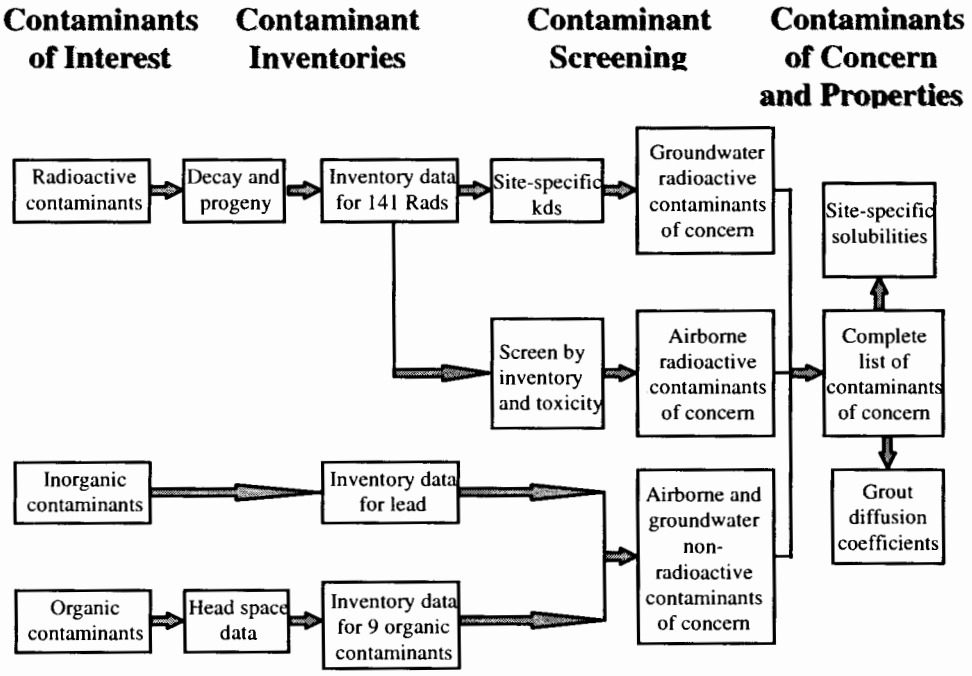

Figure I-3
Schematic of Screening Process for Contaminants of Concern

Table I-4
Contaminants of Concern for No Action Alternative 2

Contaminant	Type			
	Airborne Radioactive	Waterborne Radioactive	Inorganic	Organic
Am-241	x	---	---	---
Am-243	x	---	---	---
C-14	---	x	---	---
Cm-243	---	x	---	---
Cm-244	x	x	---	---
Cs-137	x	---	---	---
Eu-152	x	---	---	---
Np-237	---	x	---	---
Pa-233	x	---	---	---
Pu-238	x	x	---	---
Pu-239	x	x	---	---
Pu-240	x	x	---	---
Pu-241	x	---	---	---
Ra-226	x	---	---	---
Sr-90	x	---	---	---
U-233	---	x	---	---
U-234	---	x	---	---
U-235	---	x	---	---
Lead	---	---	x	---
Beryllium	---	---	x	---
Cadmium	---	---	x	---
Mercury	---	---	x	---
Carbon tetrachloride	---	---	---	x
Chloroform	---	---	---	x
Methylene chloride	---	---	---	x
1,1-Dichloroethylene	---	---	---	x
Methyl ethyl ketone	---	---	---	x
1,1,2,2-Tetrachloroethane	---	---	---	x
Toluene	---	---	---	x
Chlorobenzene	---	---	---	x
1,2-Dichloroethane	---	---	---	x
1,1,1-Trichloroethane	---	---	---	x

To conduct this screening, slightly simplified MEPAS® runs were made. These runs utilized all of the release site data and assumed unit inventories for each contaminant. The release from the waste zone was assumed to be controlled by contaminant k_d values (i.e., the release was from a soil/debris TRU waste form and was not solubility limited). Transport through the environment was also controlled by the contaminant k_d values. Because of the importance of the assumed k_d values, all MEPAS®-generated radioactive contaminant k_d values were reviewed and modified with site-specific data, where available. These MEPAS® runs produced unit impact factors for each contaminant/site pair that was multiplied by the site-specific inventory to establish the estimated impact for each contaminant at each site. Relative impacts for each contaminant were again compared and ranked. The list of radioactive contaminants whose combined impact contributed 99 percent of the total relative impact were designated as waterborne CoCs (see Table I-4).

I.6.2 Inorganic Contaminant Screening Analysis

Reliable inventory data were generally not available for the inorganic contaminants. As a result, a qualitative screening method was employed.

Lead shielding is used to reduce surface dose rates to acceptable levels for RH-TRU waste containers; therefore, lead becomes a major part of the total waste mass and is included on the CoCs list. Lead from PPE is also a major contaminant in CH-TRU waste. The lead concentrations assumed in RH-TRU and CH-TRU waste are discussed in Appendix A.

Beryllium, cadmium, and mercury were also included on the list of CoCs, based on inventory estimates from the *Waste Isolation Pilot Plant Safety Analysis Report* fire scenario (DOE 1995c). Other inorganic contaminants, such as chromium, were not included on the CoCs list because of the lack of available inventory data. The assumed inorganic concentrations in RH-TRU and CH-TRU waste are discussed in Appendix A.

I.6.3 Organic Contaminant Screening Analysis

As with inorganic contaminants, little reliable inventory data were available for the organic contaminants. Some data reported in the *Draft No-Migration Variance Petition* (DOE 1995a), however, could be used as an indirect indication of the volatile organic concentrations. The *No-Migration Variance Petition* summarized the results of a headspace sampling and analysis study conducted on TRU waste from the INEL and RFETS. This study sampled 930 drums of varying waste types to determine a weighted-average headspace-gas composition that could be used for all TRU waste. The weighted values were screened using the concentration toxicity screening technique presented by the U.S. Environmental Protection Agency in the *Risk Assessment Guidance to Superfund, Volume 1, Human Health Evaluation Manual (Part A)*, (EPA 1989). This screening provided a list of carcinogenic and noncarcinogenic contaminants that account for over 99 percent of the human health impacts resulting from airborne contamination.

I.6.4 Key Contaminants Evaluated in No Action Alternative 2

The complete list of CoCs for No Action Alternative 2 is the combination of the waterborne radioactive, airborne radioactive, inorganic, and organic contaminants shown in Table I-4. The screening analyses resulted in a combined total of 32 CoCs. Once this list of CoCs was developed, an effort was made to obtain improved values for certain contaminant properties at specific sites. The contaminant diffusion coefficient in porous cement (required to model contaminant release from cement TRU waste forms) and contaminant solubility (required to model the solubility

bounding case) were evaluated (Buck et al. 1996). Once the updated set of contaminant parameters was developed, actual waste zone contaminant release calculations were performed and flux factors for No Action Alternative 2 were generated.

I.6.5 Flux Factors

Source-term contaminant release calculations were run for all 32 CoCs for each site and for each waste-form category for a 10,000-year time period. The resulting contaminant flux factors were used to compute modular risk, which is represented as the flux factor term in Equation I-6. If a contaminant on the CoCs list was not present at a particular site, an inventory of zero was used for that calculation. Furthermore, if a particular TRU waste-form category was not present at a site, it was not considered in the flux-factor analysis. Table I-5 shows the number of nonzero flux factors produced by site and TRU waste-form category.

Table I-5
Nonzero Contaminant Flux Factors by Site and TRU Waste-Form Category

Release Site	Number of Nonzero Flux Factors	
	Soil/Debris	Cement
Hanford Site 200 East Area	30	- - -
Hanford Site 200 West Area	30	- - -
Idaho National Engineering Laboratory	32	32
Lawrence Livermore National Laboratory	28	28
Los Alamos National Laboratory	31	31
Oak Ridge National Laboratory	32	32
Rocky Flats Environmental Technology Site	25	25
Savannah River Site	29	29

I.7 WATERBORNE AND AIRBORNE TRANSPORT

The transport portion of the impact analysis required specific information related to waterborne transport, airborne transport, and receptor locations. Each area is discussed below.

I.7.1 Waterborne Transport Parameters

Parameters related to the hydrologic and geologic characteristics of each site analyzed were selected from site-specific environmental settings developed for the Draft WM PEIS (DOE 1995b) and Holdren et al. (1995). The environmental settings assumed for each of major treatment site analyzed are summarized in Buck et al. (1996). The references listed above contained the number of vadose zone layers at each site, the thicknesses and hydraulic conductivity properties of the vadose zone and aquifer layers, and a suite of physicochemical properties for all layers.

I.7.2 Calculated Waste Infiltration Rates

Flux factor calculations required additional site-specific parameters, in order to determine the waste infiltration rates needed for contaminant release calculations. Table I-6 shows MEPAS®-calculated water infiltration and soil erosion rate values for each site. The calculated rates are based on local climatology (i.e., precipitation, cloudiness, wind speed, and humidity), surface soil properties, and vegetation cover.

I.7.3 Airborne Transport Parameters

Parameters related to atmospheric release, transport, and deposition analyses required surface soil characteristics and regional climatological information. The surface soil and regional climatological information required to estimate soil suspension rates were obtained from Holdren et al. (1995). The regional meteorological data and atmospheric dispersion data, in the form of a joint frequency distribution of wind direction, wind speed, and atmospheric stability, were obtained from the Draft WM PEIS (DOE 1995b).

I.7.4 Calculated Soil Erosion Rates

Flux factor calculations required additional site-specific parameters in order to determine the soil erosion rates needed for contaminant release calculations. Table I-6 showed MEPAS®-calculated water infiltration and soil erosion rates for each site. Wind suspension and overland waterflow soil erosion rates were computed using site-specific surface soil and local climatological information. Table I-6 also provided an estimate of the amount of surface soil removed over the 10,000-year modeling period to determine whether the 1.2-meter (4-foot) overburden could be removed to expose waste to the surface.

Table I-6
MEPAS®-Calculated Water Infiltration and Soil Erosion Rates for Each Site

Category	Hanford		INEL	LANL	LLNL	ORNL	RFETS	SRS
	200E	200W						
Water Infiltration (centimeters/year)	1.49	1.49	1.43	0.663	9.28	42.2	0.156	24
Annual Precipitation (centimeters)	16	16	22	45	37	139	39	110
Percent Precipitation to Infiltration	9	9	6	1.4	25	32	0.4	22
Wind Suspension Emission Rate (grams/second)	5.5E-03	5.5E-03	0.21	4.7E-03	0.025	7.8E-06	7.7E-03	3.3
Wind Suspension Erosion Rate (centimeters/year)	5.8E-04	5.8E-04	0.045	1.3E-03	6.1E-03	3.5E-05	7.7E-03	2.0E-03
Soil Eroded by Wind in 10,000 Years (feet)	0.19	0.19	1.48	0.44	2.00	0.01	2.53	6.59
Overland Flow Emission Rate (grams/year)	5.7E+04	5.7E+04	4.9E+05	5.8E+05	1.6E+06	8.1E+04	2.0E+04	5.4E+05
Overland Flow Erosion Rate (centimeters/year)	1.9E-04	1.9E-04	3.4E-03	5.2E-03	0.014	0.012	6.5E-04	1.1E-02
Soil Eroded by Water in 10,000 Years (feet)	0.06	0.06	1.11	1.70	4.06	3.79	0.21	3.45
Total Soil Erosion in 10,000 Years (feet)	0.25	0.25	1.59	2.14	6.06	3.81	2.74	4.10

I.7.5 Air and Water Receptor Locations

Population impacts from atmospheric releases were calculated for all No Action Alternative 2 sites using site-specific joint frequency and population data. Population impacts from domestic and agricultural surface water uses were calculated for some of the sites. The atmospheric population distributions were obtained for all the sites from the Draft WM PEIS (DOE 1995b). Results of a review of the annual site reports and specific recommendations regarding population exposure for each site are summarized in Buck et al. (1996).

I.8 CALCULATION OF UNIT EXPOSURE AND UNIT IMPACT FACTORS

The human health impact analysis for SEIS-II requires definition of the unit dose factor (UDF) and the unit impact factor (UIF). The UDF relates average daily intake (milligrams per kilogram per day) for chemicals and lifetime radiation dose (rem) for radionuclides. The UIF relates intake or dose to impact or hazard index for each pollutant, as appropriate. The UIF and UDF are defined for contaminant inhalation and ingestion and for external radiation exposure. The following sections describe the calculation of UDF and UIF from the health impact endpoint values provided in the MEPAS® output files for both individual and population exposures. Parameter arrays can also be calculated from information in the MEPAS® output files. Background information and the scope of the analysis are summarized first.

I.8.1 Background Information and Scope of Analysis

SEIS-II project analysis requires calculation of population health impacts as well as individual health impacts. The UIF values for individual and population exposures are the same and provide conversion from intake or dose to impact. These values are based on slope factors, reference doses, and radiation dose conversion factors. The UDF values differ from UIF values, in that the population UDF is evaluated using average parameter values instead of 90th percentile values. The number of people exposed is not included in UDF or UIF values; however, the population exposed must be included in the final analysis of impact, because populations are defined for each release site and receptor location. The UDF and UIF values are independent of release site and receptor location.

Many combinations of variables must be used to generate the UDF and UIF. These variables are described below.

I.8.1.1 Exposure Scenario

Analyses are performed for an MEI and for local populations. Both scenarios involve the potential exposure to air, soil, and waterborne contamination.

I.8.1.2 Receptor Type

Like the exposure scenario, MEI and local population receptor types are evaluated for No Action Alternative 2. Each receptor type requires the generation of specific UIF/UDF files; they cannot be combined into one calculation.

I.8.1.3 Exposure Media

Each analysis is performed with the appropriate exposure media for the MEI and local population scenarios. Types of exposure media include soil per unit mass, soil per unit area, air, and groundwater.

I.8.1.4 Pollutant Type

Specific output files are generated for each type of pollutant: noncarcinogenic chemicals, carcinogenic chemicals, and radionuclides. As with previous analyses, the list of chemicals in the two chemical file types is identical. All chemicals are analyzed for carcinogenic risk and noncarcinogenic hazard quotient. Chemical types that are not appropriate for a specific chemical will result in a zero health impact result.

I.8.2 Individual UDF and UIF Calculations

The results from individual UDF and UIF calculations provide the cancer incidence risk and hazard index values for the following parameters: each exposure pathway, each pollutant, one scenario, one pollutant type, and one set of up to 20 pollutants. These parameters are referred to as unit exposure factors. The file also contains the slope factors and reference doses used for chemicals in the analysis. MEPAS® assimilates the data and a postprocessor program extracts the UDF and UIF from each output file, as necessary, for subsequent calculations. For each set of results, the UDF values are summed over the specific values for each exposure pathway within an exposure route. The calculation output is a set of UDF values for each pollutant, calculated from the risk/hazard quotient values that are described in more detail in Buck et al. (1996).

Because all radiation risk conversion calculations use the same conversion factor, the UIF for all radionuclides and exposure routes is one value. For calculation of total cancer incidence, the UIF is set to 7.3×10^{-4} risk per rem. For total cancer fatalities, the UIF is set to 6.3×10^{-4} risk per rem.

I.8.3 Population UDF and UIF Calculations

Population UDF and UIF values are calculated according to the equations for individual UDF and UIF values (Equation I-5 and I-6). Population UDF, risk and hazard quotient values in the output files, however, must be taken from files generated specifically for population exposures. The population UIF value should be numerically equal to the individual UIF value.

I.9 SUMMARY OF LONG-TERM IMPACTS OF NO ACTION ALTERNATIVE 2

This section provides a summary of long-term impacts from stored TRU waste at the major generator-storage sites for 10,000 years following loss of institutional control. The analysis of human health impacts estimates TRU waste as a source of direct exposure and as a contaminant source for release to surface and subsurface exposure points in the environment. Scenarios analyzed included: direct exposure to wastes; direct exposure to waterborne and airborne releases of contaminants from wastes stored in shallow, earth-covered trenches or earthen berms; and direct exposure to wastes stored in exposed surface pads or in surface enclosures and buildings.

The impacts to human health from waste intrusion and long-term environmental release were estimated using methods outlined in Appendix H and in Buck et al. (1996). This analysis focused

on the impacts of waste at the seven major treatment sites, because the majority (99 percent) of the wastes generated are stored at these sites. Estimates for RH-TRU waste impacts were only made for sites storing RH-TRU waste (i.e., Hanford, INEL, LANL, and ORNL). No estimates of impacts were made for either CH-TRU or RH-TRU wastes buried at LLNL and RFETS, because neither of these sites store wastes in buried configurations.

I.9.1 Impacts from Intrusion into Wastes

The following are radiological and hazardous chemical impacts to hypothetical intruders from buried and surface-stored wastes.

I.9.1.1 Buried Waste Storage

With the loss of institutional control, an inadvertent intruder could become directly exposed to waste stored in shallow burial facilities. One scenario postulates that an individual would drill into the waste and become exposed to waste material brought to the land surface by the drilling process. Another scenario assumes that an individual would farm in soil contaminated by the waste materials and would ingest contaminated materials and eat produce from the garden. To bound the impact, calculations assumed the intrusions occurred at loss of institutional control. The analyses performed for both CH-TRU and RH-TRU wastes are summarized below.

The estimated maximum dose to a hypothetical driller from exposure to CH-TRU ranged from about 0.03 to 0.18 rem, which corresponds to 1.5×10^{-5} to 9.0×10^{-5} LCFs for the five sites with buried wastes (Table I-7). The estimated maximum dose to a hypothetical driller from RH-TRU wastes ranged from 0.01 to 0.76 rem, which corresponds to 6.6×10^{-6} to 3.8×10^{-4} LCFs over the four sites that store RH-TRU wastes (Table I-8).

The estimated maximum dose for the gardener exposed to CH-TRU waste ranged from 0.36 to 8.7 rem, which corresponds to 1.8×10^{-4} to 4.4×10^{-3} LCFs (Table I-7). The estimated maximum dose to the gardener from RH-TRU wastes ranged from 0.36 to 6.4 rem, which corresponds to 1.8×10^{-4} to 3.2×10^{-3} LCFs (Table I-8). The highest estimated dose for CH-TRU wastes was calculated for SRS for both the driller and gardener scenarios. The highest estimated dose for RH-TRU wastes was calculated for Hanford for both scenarios.

Health impacts from hazardous chemicals, including volatile organic compounds (VOC), are found to be negligible when compared to radiological impacts (see Tables I-7 and I-8).

I.9.1.2 Surface-Stored Wastes

With the loss of institutional control, inadvertent intruders will be more likely to come into direct contact with waste in surface storage facilities than with buried waste. To estimate this impact, exposure calculations were performed for a hypothetical scavenger intruder in contact with surface-stored wastes during a 24-hour period at loss of institutional control. The scavenger is assumed to be exposed via inhalation of resuspended contamination and external and inadvertent ingestion of contaminated soil while at the site.

Table I-7
Summary of Radiological and Hazardous Chemical Impacts from Drilling Intrusion into CH-TRU Wastes

Radiological Impacts					
Radionuclide	**Hanford**	**INEL**	**LANL**	**ORNL**	**SRS**
Driller Impacts (rem)					
Co-60	0	0	0	0	0
Sr-90	8.1E-06	1.7E-07	5.8E-07	1.5E-04	1.6E-07
Y-90	1.1E-05	2.3E-07	8.1E-07	2.0E-04	2.2E-07
Cs-137	1.1E-03	7.0E-05	8.6E-05	0.03	2.4E-05
Pu-238	3.9E-03	1.5E-03	6.2E-03	2.1E-03	0.08
Pu-239	3.0E-03	2.0E-03	0.01	2.9E-03	5.0E-03
Pu-240	6.9E-04	4.8E-04	1.3E-05	9.5E-04	1.2E-03
Am-241	0.02	0.14	0.04	0.10	0.09
Cm-244	3.2E-06	1.1E-05	8.1E-06	4.2E-04	5.8E-08
Np-239	3.0E-07	8.9E-07	1.4E-05	3.3E-04	9.1E-08
Total (rem)	0.03	0.14	0.06	0.14	0.18
LCF	1.5E-05	7.1E-05	3.0E-05	7.0E-05	9.0E-05
Gardener Impacts (rem)					
Co-60	0	0	0	0	0
Sr-90	4.7E-03	9.6E-05	0.11	0.09	9.1E-05
Y-90	3.0E-04	6.2E-06	7.1E-03	5.5E-03	5.9E-06
Cs-137	4.6E-03	3.0E-04	0.12	0.13	1.0E-04
Pu-238	0.36	0.13	2.3E-03	0.19	7.65
Pu-239	0.27	0.19	0.13	0.27	0.46
Pu-240	0.06	0.04	0	0.09	0.11
Am-241	0.12	0.79	0	0.58	0.51
Cm-244	1.8E-05	6.1E-05	0	2.4E-03	3.3E-07
Np-239	1.2E-09	3.6E-09	0	1.3E-06	3.7E-10
Total (rem)	0.82	1.16	0.36	1.35	8.74
LCF	4.1E-04	5.8E-04	1.8E-04	6.8E-04	4.4E-03

Hazardous Chemical Impacts		
Driller Impacts		
Hazardous Chemical	**PEL**	**Cancer Incidence**
Cadmium	9.8E-05	1.4E-12
Beryllium	0.02	1.3E-10
Lead	0.03	
Mercury	0.01	
Gardener Impacts		
Hazardous Chemical	**Hazard Quotient**	**Cancer Incidence**
Cadmium	4.4E-07	0.01
Beryllium	3.0E-04	0.51
Lead	1.0E-03	
Mercury	1.0E-08	

LCF = Latent Cancer Fatalities

Table I-8
Summary of Radiological and Hazardous Chemical Impacts from Drilling Intrusion into RH-TRU Wastes

Radiological Impacts				
Radionuclide	**Hanford**	**INEL**	**LANL**	**ORNL**
Driller Impacts (rem)				
Co-60	0	0	0	0
Sr-90	4.6E-03	1.8E-03	7.6E-05	2.0E-03
Y-90	6.4E-03	2.5E-03	1.0E-04	2.8E-03
Cs-137	0.68	0.12	0.01	0.08
Pu-238	1.4E-04	4.6E-05	1.8E-05	1.1E-05
Pu-239	2.3E-03	2.3E-04	1.4E-03	8.4E-05
Pu-240	1.1E-03	9.0E-05	0	1.5E-05
Am-241	0.07	0.01	1.7E-06	4.7E-03
Cm-244	0	0	0	0
Np-239	0	0	0	0
Total (rem)	0.76	0.13	0.01	0.09
LCF	3.8E-04	6.5E-05	6.6E-06	4.6E-05
Gardener Impacts (rem)				
Co-60	0.0E+00	0	0	0
Sr-90	2.66	1.04	0.11	1.17
Y-90	0.17	0.07	0.01	0.08
Cs-137	2.88	0.50	0.12	0.35
Pu-238	0.01	4.2E-03	2.3E-03	9.7E-04
Pu-239	0.21	0.02	0.13	0.01
Pu-240	0.10	0.01	0	1.4E-03
Am-241	0.41	0.05	0	0.03
Cm-244	0	0	0	0
Np-239	0	0	0	0
Total (rem)	6.45	1.69	0.36	1.64
LCF	3.2E-03	8.4E-04	1.8E-04	8.2E-04

Hazardous Chemical Impacts		
Driller Impacts		
Hazardous Chemical	**PEL**	**Cancer Incidence**
Cadmium	9.8E-05	1.4E-12
Beryllium	0.02	1.3E-10
Lead	0.03	
Mercury	0.01	
Gardener Impacts		
Hazardous Chemical	**Hazard Quotient**	**Cancer Incidence**
Cadmium	4.4E-07	0.01
Beryllium	3.0E-04	0.51
Lead	1.0E-03	
Mercury	1.5E-03	

LCF = Latent Cancer Fatalities

The estimated maximum dose to a hypothetical scavenger exposed to surface-stored CH-TRU wastes ranged from about 1.3 to 37.6, which corresponds to 6.4 x 10^{-4} to 0.02 LCFs (Table I-9). The estimated maximum dose to the scavenger from surface-stored RH-TRU wastes ranged from about 1.4 to 24.5, which corresponds to 6.9 x 10^{-4} to 1 x 10^{-2} LCFs (Table I-9). For CH-TRU wastes, the highest doses were estimated at RFETS. The highest doses for RH-TRU wastes were estimated for Hanford and INEL.

Another potential intruder scenario involves a hypothetical family (2 adults and 2 children) that lives and farms on a plot of land immediately over the surface-stored waste, where the waste has degraded and become indistinguishable from the surrounding land. For these conditions, the maximally exposed intruder in the family could be exposed via ingestion of contaminated food crops grown in the contaminated soil, inhalation of resuspended contamination, external exposure to the soil, and inadvertent ingestion of contaminated soil. If this scenario occurred, the four-member family would likely receive severe and potentially lethal doses over the 30-year exposure period (i.e., in excess of 400 rem per year). Estimated LCFs for this scenario range from 0.24 to 7.11 for CH-TRU waste and 0.33 to 6.4 for RH-TRU waste. Table I-10 gives a summary of estimated radiological doses and resulting LCFs for all sites.

Table I-9
Summary of Radiological Impacts from Scavenger Intrusion into Surface-Stored Wastes (All Sites)

Radionuclide	Hanford	INEL	LLNL	LANL	ORNL	RFETS	SRS
CH-TRU Waste Impacts (rem)							
Sr-90	4.9E-05	1.0E-06	0	3.5E-06	8.9E-04	0	1.0E-06
Y-90	3.3E-04	6.8E-06	0	2.4E-05	6.0E-03	0	6.8E-06
Cs-137	0.03	2.2E-03	4.5E-09	2.7E-03	1.00	0	7.7E-04
Pu-238	1.37	0.51	0.07	2.16	0.73	0.22	19.01
Pu-239	1.05	0.71	0.35	3.52	1.03	12.04	0.76
Pu-240	0.24	0.17	0.14	0.00	0.34	4.83	0.19
Am-241	0.42	2.81	0.73	0.89	2.05	20.51	0.81
Cm-244	6.4E-05	2.1E-04	3.3E-03	1.6E-04	0.01	0	2.2E-03
U-233	1.4E-03	6.9E-03	2.0E-10	8.9E-04	0.03	2.5E-03	1.4E-04
Total (rem)	3.11	4.22	1.29	6.58	5.19	37.60	21
LCF	1.6E-03	2.1E-03	6.4E-04	3.3E-03	2.6E-03	0.02	0.01
RH-TRU Waste Impacts (rem)							
Sr-90	0.03	0.01	N/A	1.1E-03	0.01	N/A	N/A
Y-90	0.19	0.07	N/A	7.7E-03	0.08	N/A	N/A
Cs-137	21.51	3.74	N/A	0.89	2.63	N/A	N/A
Pu-238	0.05	0.02	N/A	8.6E-03	3.7E-03	N/A	N/A
Pu-239	0.81	0.08	N/A	4.8E-01	0.03	N/A	N/A
Pu-240	0.40	0.03	N/A	0	0.01	N/A	N/A
Am-241	1.47	0.17	N/A	0	0.10	N/A	N/A
Cm-244	0	3.4E-03	N/A	0	4.3E-03	N/A	N/A
U-233	1.4E-03	1.1E-04	N/A	1.8E-06	1.6E-05	N/A	N/A
Total (rem)	24.46	4.13	N/A	1.39	2.86	N/A	N/A
LCF	0.01	2.1E-03	N/A	6.9E-04	1.4E-03	N/A	N/A

LCF = Latent Cancer Fatalities

Table I-10
Summary of Radiological Impacts from Farm Family Intrusion into Surface-Stored Wastes (All Sites)

Radionuclide	Hanford	INEL	LLNL	LANL	ORNL	RFETS	SRS
CH-TRU Waste Impacts (rem)							
Sr-90	11.37	0.23	0	0.82	207.01	0	0.23
Y-90	0.77	0.02	0	0.06	14.11	0	0.02
Cs-137	7.79	0.50	1.0E-06	0.61	225.61	0	0.17
Pu-238	505.65	190.07	25.61	797.99	270.28	80.92	7.0E+03
Pu-239	363.71	247.79	120.92	1.2E+03	358.53	4.2E+03	262.79
Pu-240	84.27	58.89	47.09	1.60	116.75	1.7E+03	64.37
Am-241	167.68	1.1E+03	294.90	361.08	826.30	8.3E+03	329.10
Cm-244	0.02	0.08	1.23	0.06	3.21	0	0.84
U-233	0.55	2.67	7.8E-08	0.34	10.53	0.96	0.05
Total (rem)	1.1E+03	1.6E+03	489.76	2.4E+03	2.0E+03	1.4E+04	7.7E+03
LCF	0.57	0.82	0.24	1.19	1.02	7.11	3.84
RH-TRU Waste Impacts (rem)							
Sr-90	6.5E+03	2.5E+03	N/A	265.16	2.8E+03	N/A	N/A
Y-90	440.34	172.44	N/A	18.09	194.21	N/A	N/A
Cs-137	4.9E+03	845.14	N/A	200.61	592.75	N/A	N/A
Pu-238	17.81	5.91	N/A	3.18	1.37	N/A	N/A
Pu-239	281.13	28.00	N/A	167.01	10.28	N/A	N/A
Pu-240	138.89	10.97	N/A	0	1.80	N/A	N/A
Am-241	593.64	67.23	N/A	0	38.64	N/A	N/A
Cm-244	0	1.29	N/A	0	1.62	N/A	N/A
U-233	0.55	0.04	N/A	7.0E-04	0.01	N/A	N/A
Total (rem)	1.3E+04	3.7E+03	N/A	654.06	3.7E+03	N/A	N/A
LCF	6.39	1.83	N/A	0.33	1.84	N/A	N/A

As in the case of buried wastes, health impacts of hazardous chemicals, including VOCs contained within TRU wastes, are estimated to be very small relative to the severe radiological impacts. The one exception would be exposure from mercury, where the hazard index was estimated to be 6.

I.9.2 Long-Term Impacts of Environmental Release

Contaminants in TRU wastes stored in shallow burial trenches and surface storage facilities within site-specific environmental settings would eventually be released to the surrounding environments at the generator-storage sites. Contaminants within the buried or surface-stored wastes would be leached and released to underlying soils and aquifer systems at depth. Eventually, at most sites, contaminants would reach groundwater and migrate laterally to downgradient receptor locations. Contaminants may also eventually be discharged into nearby surface-water bodies, particularly at the Hanford, ORNL, and SRS sites. Once in these surface-water systems, dilute concentrations of the contaminants would become available to the public in nearby communities.

Wastes stored in surface facilities would also degrade and become available in the environment as a result of cyclic and ongoing processes, such as direct water and air erosion, deposition onto soils surrounding the site, and resuspension of contaminated soils in air. The general surrounding on-site and off-site populations would be exposed to contaminants redistributed into the environment by these processes.

For this analysis, the impacts to the hypothetical farm living 300 meters (980 feet) downgradient of the waste storage area were estimated. It is assumed that the family would engage in farming activities such as growing and consuming their own crops and livestock. The family uses contaminated groundwater as a source of drinking water for themselves and the animals and for watering the crops. The MEI would be exposed via ingestion of food crops grown in the contaminated soil, inhalation of resuspended contamination, external exposure to the soil, and inadvertent ingestion of contaminated soil. This analysis also considered the off-site population that could potentially be exposed to environmental releases to the surface water and air. For analyses of buried waste releases, all CH-TRU and RH-TRU waste was combined into a single waste disposal unit, and only the groundwater pathway was considered. For analyses of surface-stored waste releases, all CH-TRU and RH-TRU wastes were combined into a single waste storage unit and were allowed to be released to all pathways.

The radiological and hazardous chemical population impacts estimated for this alternative are based on current storage-site population distributions. At present, most sites are remote from large population centers. While it is unknown how populations at the sites will change over the next 10,000 years, populations may increase substantially over present day levels and encroach onto sites and near storage facilities. The latter point is certainly implied for the inadvertent human intrusion scenarios. Thus, the potential for additional impacts may increase and potential long-term radiological and hazardous chemical impacts could be considerably higher (i.e., an order of magnitude or more) than those estimated in this analysis.

I.9.2.1 Radiological Impacts

The estimated lifetime radiological impacts over 10,000 years, as a result of environmental contaminant releases from buried and surface-stored wastes at the seven generator-storage sites, are summarized in Table I-11. The maximum lifetime MEI radiological impact for all sites ranged from 1.5×10^{-3} to 14.5 rem per year. Resultant LCFs ranged from 7.5×10^{-7} to 7.7×10^{-3}. The highest lifetime LCF is estimated for RFETS.

The estimated lifetime radiological population impacts were determined from the air and surface water pathway exposure for all sites. The groundwater pathway was not considered to be a notable source of off-site drinking water, so it was not considered in the estimation of off-site population impacts. The estimated maximum lifetime population radiological impacts for all sites (see Table I-11) ranged from 0.6 to 42,000 person-rem per lifetime. The resultant LCFs ranged from 3.2×10^{-4} to 20.9. The highest impact was estimated at the RFETS, where the calculated risk was over an order of magnitude higher than any other site. The aggregated impact from all sites over 10,000 years was estimated to result in 2,325 latent cancer fatalities.

Summary plots of site-specific radiological impacts for all long-term environmental impact analysis are provided in Figures I-4 and I-5.

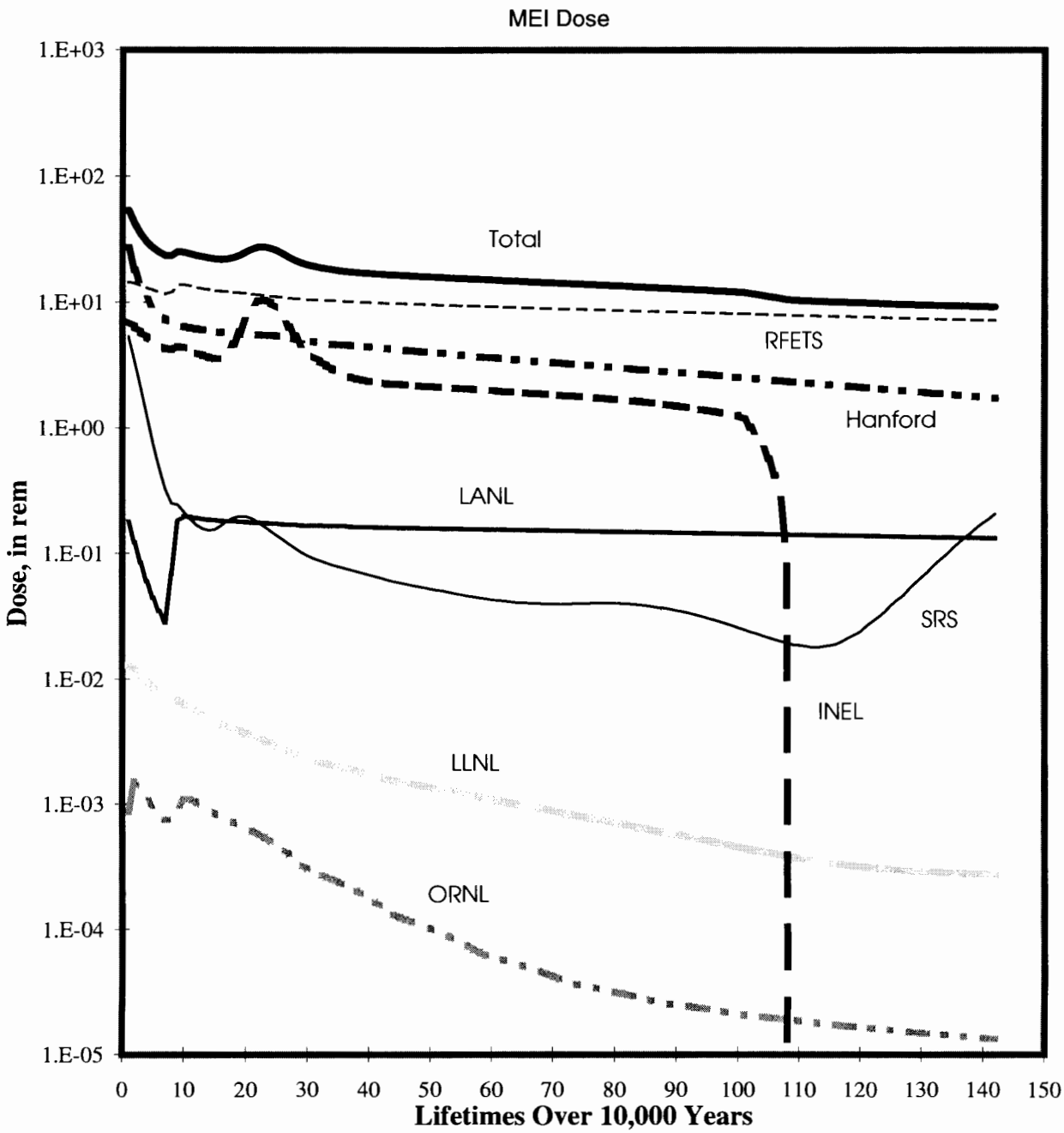

Figure I-4
Summary of Site-Specific Radiological Impacts for Maximally Exposed Individuals for all Lifetimes over 10,000 Years. Each Lifetime Represents a 70-year Time Period.

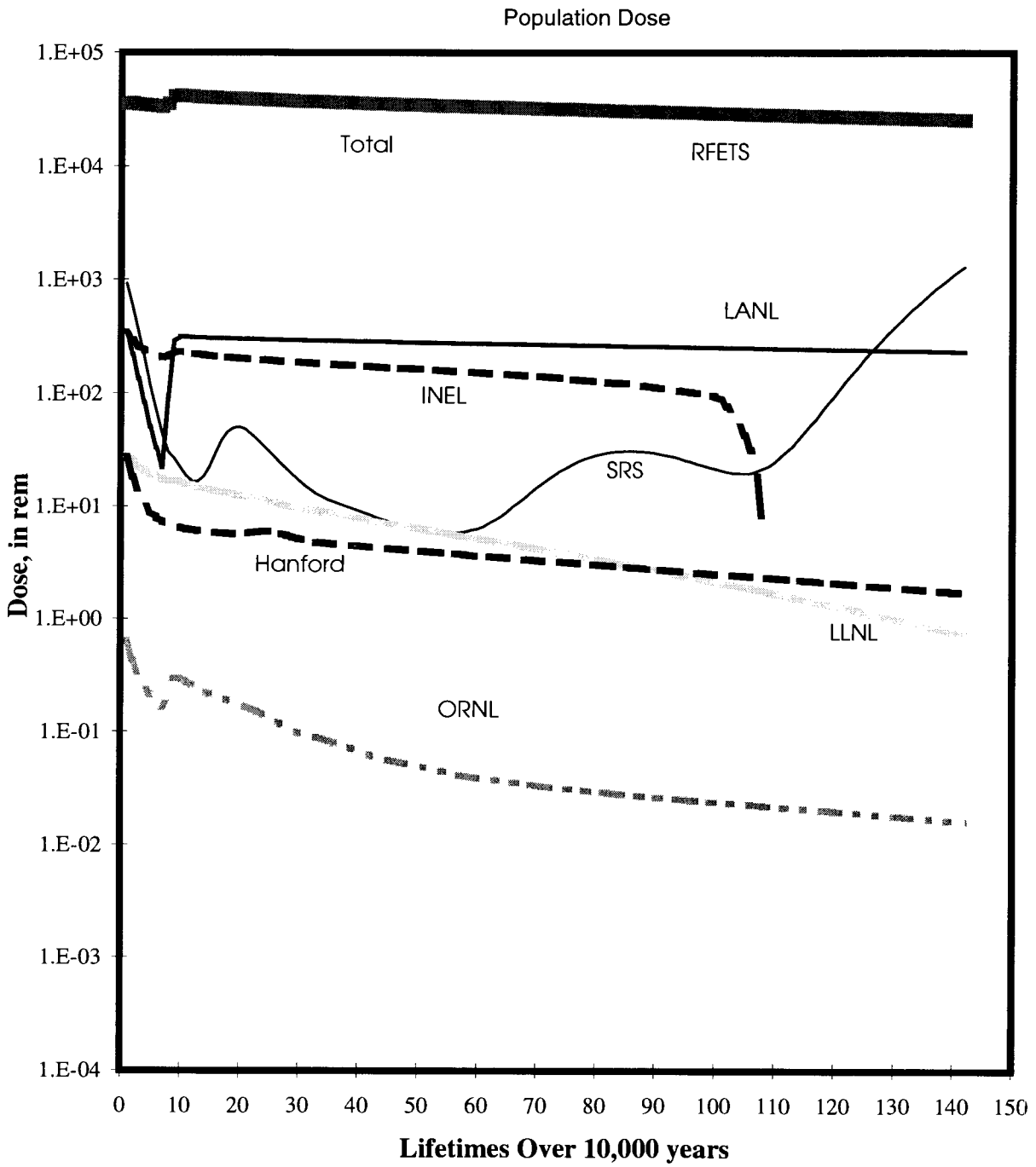

Figure I-5
Summary of Site-Specific Radiological Impacts for the General Population for all Lifetimes over 10,000 Years. Each Lifetime Represents a 70-year Time Period.

Table I-11
Summary of Maximum Lifetime MEI and Population Impacts from Buried and Surface-Stored Wastes to Exposed Populations after Loss of Institutional Control for Seven Major Generator-Storage Sites

	Radiological Impacts			Chemical Carcinogenic Impacts	
Site	Lifetime Dose(rem/year)	Lifetime LCF	Dominant Pathway	Lifetime Cancer Incidence	Dominant Pathway
MEI Impacts					
Hanford	1.7	8.5 E-04	Air Inhalation	1.0E-04	Groundwater Ingestion
INEL	10.48	3.5 E-03	Groundwater Ingestion	4.7E-03	Groundwater Ingestion
LANL	0.2	8.9 E-05	Air Inhalation	2.5E-07	Air Inhalation
LLNL	0.01	6.5 E-06	Air Inhalation	5.0E-06	Groundwater Ingestion
ORNL	1.5E-03	7.5E-07	Groundwater Ingestion	5.9E-07	Groundwater Ingestion
RFETS	14.5	7.7 E-03	Air Inhalation	2.1E-07	Groundwater Ingestion
SRS	5.38	2.7 E-03	Air Inhalation	3.1E-04	Groundwater Ingestion
Population Impacts					
Hanford	27	0.01	Air Inhalation	7.5E-09	Air Inhalation
INEL	329	0.2	Air Inhalation	5.8E-06	Air Inhalation
LANL	349	0.2	Air Inhalation	4.7E-04	Air Inhalation
LLNL	28.3	0.01	Air Inhalation	2.5E-07	Air Inhalation
ORNL	0.6	3.2 E-04	Air Inhalation	4.9E-07	Surface Water Ingestion
RFETS	4.2E+04	20.9	Air Inhalation	7.4E-04	Air Inhalation
SRS	1.3E+03	0.65	Surface Water Ingestion	1.1E-07	Surface Water Ingestion

I.9.2.2 Chemical Carcinogen Impacts

The estimated maximum lifetime cancer incidence from chemical carcinogens to an MEI (see Table I-11) ranged from 2.1×10^{-7} to 4.7×10^{-3} over the seven sites. The highest cancer incidence was estimated for INEL. The predominant impacts at nearly all sites, except LANL, resulted from ingestion of groundwater containing 1,1,2,2-tetrachloroethane.

The estimated maximum lifetime cancer incidence for exposed populations (see Table I-11) was estimated to range from 7.5×10^{-9} to 7.4×10^{-4} over the seven sites. The aggregated lifetime cancer incidence for the seven sites over 10,000 years was estimated at 0.25.

I.9.2.3 Noncarcinogenic Impacts

The impact from noncarcinogenic chemicals was very low compared to the radiological impact. Maximum hazard indices from noncarcinogens to an MEI were estimated for the seven sites (see Table I-12), where they ranged from 1.5×10^{-4} to 3.2. The highest hazard index was estimated for the SRS. The predominant impacts at all sites resulted from ingestion of groundwater containing either mercury or carbon tetrachloride.

Table I-12
Summary of Noncarcinogenic Impacts from Buried and Surface-Stored Wastes to a Maximally Exposed Individual after Loss of Institutional Control for Seven Major Generator-Storage Sites

Site	Maximum Hazard Index	Key Chemical	Dominant Pathway
Hanford	0.02	Mercury	Groundwater Ingestion
INEL	0.4	Carbon Tetrachloride	Groundwater Ingestion
LANL	3.1E-3	Mercury	Resuspended Soil Ingestion
LLNL	6.2E-4	Carbon Tetrachloride	Groundwater Ingestion
ORNL	3.2E-4	Mercury	Groundwater Ingestion
RFETS	1.5E-4	Carbon Tetrachloride	Groundwater Ingestion
SRS	3.2	Mercury	Groundwater Ingestion

I.10 REFERENCES CITED IN APPENDIX I

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APPENDIX J

APPENDIX J
LIST OF PREPARERS AND CONTRIBUTORS

This list identifies individuals who were principal preparers and contributors to this supplemental environmental impact statement (SEIS-II). Harold Johnson of the Department of Energy's Carlsbad Area Office directed the preparation of SEIS-II. Glen T. Hanson of Battelle's Albuquerque Office provided overall project management, as well as technical and document preparation support. Tracy A. Ikenberry provided management of the technical staff at DOE's Pacific Northwest National Laboratory (managed and operated by Battelle).

Name: STEPHEN R. ALCORN

Affiliation: Battelle - Albuquerque

Education:
- Ph.D., Geology (Geochemistry), University of Georgia, 1981
- M.S., Geology, University of South Carolina, 1975
- A.B., Geology, Lafayette College, 1969

Technical Experience: Seventeen years of experience as an environmental scientist, expert consultant, and manager of hazardous and radioactive waste projects, in the areas of geology and geochemistry, site modeling and contaminant transport analysis, site assessment and remediation, performance assessment, and environmental compliance.

EIS Responsibility: Technical reviewer, contributed to the geology and hydrology sections of Chapter 4, and Appendix H.

Name: DAVID M. ANDERSON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Forest Economics, Oregon State University, 1991
- B.S., Forest Resources, Oregon State University, 1989

Technical Experience: Six years of experience with regional economic and socioeconomic analysis modeling.

EIS Responsibility: Contributed to the socioeconomics sections of chapters 4 and 5.

Name: MICHELLE R. AQUINO

Affiliation: Battelle - Albuquerque

Education:
- M.S., Radiological Sciences and Control, University of Lowell, 1991
- B.H.S., Medical Technology, University of Missouri - Columbia, 1984

Technical Experience: Five years of health physics and technical writing experience.

EIS Responsibility: Quality Assurance Manager. Also, assisted in the technical reviews and editing of the document.

Name: LARRY M. BAGAASEN

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Ceramic Engineering, University of Illinois, 1983
- B.S., Ceramic Engineering, University of Illinois, 1981

Technical Experience: Twelve years of experience in ceramic fabrication, cement waste form development, and systems modeling of remediation technologies.

EIS Responsibility: Contributed to the assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: LISA E. BARVA

Affiliation: Battelle - Albuquerque

Education:
- B.A., Spanish, University of New Mexico, 1996
- A.A., Court and Conference Reporting, Ferris State College, 1984

Technical Experience: Seven years of experience in word processing.

EIS Responsibility: Contributed to the production of the document.

Name: JAMES M. BECKER

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Range and Wildlife Resources, Brigham Young University, 1987

Technical Experience: Five years of experience in planning and conducting field surveys of terrestrial wildlife and plant taxa.

EIS Responsibility: Prepared the biology section of Chapter 5.

Name: MARCEL P. BERGERON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.A., Geology, Indiana University, 1979
- B.A., Geology, University of Vermont, 1975

Technical Experience: Seventeen years of experience in a variety of hydrologic studies at hazardous waste and contaminated ground water sites.

EIS Responsibility: Deputy Project Manager, PNNL activities. Lead preparer for assessment of the post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: JOHN W. BUCK

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Meteorology, University of Wisconsin, 1980
- B.S., Meteorology, University of Wisconsin, 1978

Technical Experience: Fifteen years of experience in energy research, multi-media transport and exposure assessment, and risk assessment.

EIS Responsibility: Technical lead, assessment of the post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: KARL CASTLETON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Computer Science and Applied Mathematics, Mesa State College, 1992

Technical Experience: Four years of experience in environmental assessment modeling.

EIS Responsibility: Contributed to the assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: SALVATORE DIMARIA

Affiliation: Battelle - Albuquerque

Education:
- M.A., Geography, University of New Mexico, 1988
- B.S., Biology, University of New Mexico, 1972

Technical Experience: Eight years of experience with geographical, biological, and quantitative research methods.

EIS Responsibility: Technical lead for Chapter 4; prepared the biotic resources, land use, and generator site sections of Chapter 4; also prepared the list of agencies and persons consulted.

Name: JAMES F. DONAGHUE

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- J.D., Law, Golden Gate University, 1990
- B.S., Civil Engineering, University of Arkansas, 1985

Technical Experience: Seven years of experience in environmental management and regulatory compliance.

EIS Responsibility: Contributed to Appendix A.

Name: FRANCIS C. DOUGLAS

Affiliation: Battelle – Albuquerque

Education:
- M.A., English, Kansas State University, 1994
- B.S., Journalism, Ohio University, 1982

Technical Experience: Eighteen years of experience as a writer and editor, including three years serving the environmental industry.

EIS Responsibility: Deputy Project Manger - Battelle - Albuquerque, document support. Conducted editorial reviews of the document.

Name: AMY S. DUDA

Affiliation: Battelle - Albuquerque

Education:
- B.A., English, University of New Mexico, 1996

Technical Experience: Five years of experience in editing.

EIS Responsibility: Assisted in the technical editing of the document.

Name: THOMAS A. EDWARDS

Affiliation: Battelle - Albuquerque

Education:
- B.S., Nuclear Engineering, University of New Mexico, 1992

Technical Experience: Five years of experience in health physics, waste management, ALARA reviews and audits, emergency response, industrial hygiene, and remote handled waste.

EIS Responsibility: Prepared the sections on background radiation levels at WIPP in Chapter 4 and contributed to transportation section of Chapter 5 and Appendix E.

Name: PAUL W. ESLINGER

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Statistics, Southern Methodist University, 1983
- M.S., Mathematics, Washington State University, 1978
- B.S., Mathematics, George Fox College, 1976

Technical Experience: Seventeen years of experience in risk assessment, dose reconstruction, and performance assessment modeling.

EIS Responsibility: Lead preparer, Appendix B and the performance assessment sections of Chapter 5 and Appendix H.

Name: CHRISTIAN J. FOSMIRE

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Meteorology, Pennsylvania State University, 1993
- B.S., Meteorology, Pennsylvania State University, 1990

Technical Experience: Two years of experience in atmospheric diffusion modeling and risk assessment.

EIS Responsibility: Prepared the air quality sections of Chapter 5 and Appendix C.

Name: GARIANN GELSTON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Applied Mathematics, Mesa State College, 1991

Technical Experience: One year of experience in environmental assessment modeling.

EIS Responsibility: Modeled nonradiological impacts for the human health and facility accidents sections of Chapter 5 and appendices F and G, and contributed to assessment of post-institutional control period for the No Action Alternative 2 in Chapter 5 and Appendix I.

Name: GLEN T. HANSON

Affiliation: Battelle - Albuquerque

Education:
- M.A., Anthropology/Archaeology, Arizona State University, 1976
- B.S., Anthropology/Archaeology, Grand Valley State College, 1971

Technical Experience: Twenty-four years of experience in environmental and resource management, regulatory compliance, environmental assessment and impact analyses for NEPA documentation, facility siting, site characterization, cultural resource assessment and management, and environmental program management.

EIS Responsibility: Project Manager - Battelle - Albuquerque. Conducted technical and management reviews of the document.

Name: PAUL L. HENDRICKSON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- J.D., Law, University of Washington, 1971
- M.S., Industrial Management, Purdue University, 1972
- B.S., Chemical Engineering, University of Washington, 1968

Technical Experience: Twenty-three years of experience in energy and environmental studies with special emphasis on regulatory issues.

EIS Responsibility: Prepared the sections on land use impacts in Chapter 5.

Name: JAMES A. HILEMAN

Affiliation: Battelle - Albuquerque

Education:
- Ph.D., Seismology, California Institute of Technology, 1977
- M.S., Seismology, California Institute of Technology, 1971
- Geophysical Engineer, Colorado School of Mines, 1960

Technical Experience: Thirty years of experience in exploration, research, management, and review, particularly in siting critical facilities and assessing geologic hazards.

EIS Responsibility: Contributed to sections of Chapter 3.

Name: TRACY A. IKENBERRY

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Radiology & Radiation Biology, Colorado State University, 1982
- B.A., Biology, McPherson College, 1979

Technical Experience: Thirteen years of experience in radiological assessment, operational and environmental health physics. Diplomate, American Board of Health Physics, 1988.

EIS Responsibility: Project Manager, PNNL activities. Lead preparer, Appendix B. Technical and management reviewer.

Name: HAROLD JOHNSON

Affiliation: U.S. Department of Energy

Education:
- J.D., Law, Mercer University, 1976
- B.S., Math and Physics, Mercer University, 1971

Technical Experience: Nine years of experience in writing, reviewing, and approving NEPA documents.

EIS Responsibility: DOE document manager.

Name: CHRISTINE D. LADD

Affiliation: Battelle - Albuquerque

Education
- Certified in the beginning, intermediate, and advanced levels of Adobe Illustrator, University of New Mexico, 1995

Technical Experience: Two years of experience in document production and graphics design.

EIS Responsibility: Contributed to the design of the graphics and production of the document.

Name: DAVID LECHEL

Affiliation: Lechel, Inc.

Education:
- M.S., Fisheries Biology, Michigan State University, 1974
- B.S., Fisheries Biology, Michigan State University, 1972

Technical Experience: Twenty-two years of experience in project management, regulatory compliance and permitting, NEPA planning and implementation for hazardous and radioactive waste disposal facilities.

EIS Responsibility: Technical reviewer, lead preparer of Chapter 2, and assisted in the development of alternatives.

Name: ROBERT A. LECHEL

Affiliation: Battelle - Albuquerque

Education:
- B.S., Environmental Studies and Planning: Hazardous Materials Management, California State University - Sonoma, 1995

Technical Experience: One year of experience in performance assessment modeling.

EIS Responsibility: Contributed to the transportation sections of Chapter 5 and Appendix E.

Name: MARCUS K. LESTER

Affiliation: Battelle – Seattle Research Center

Education:
- M.A., Geography, University of Washington, 1991
- B.A., Geography, University of Washington, 1989

Technical Experience: Six years of experience in cartography, geographic information systems (GIS), and spatial analysis of environmental and socioeconomic data.

EIS Responsibility: Prepared the environmental justice section of Chapter 4.

Name: GEORGE A. MARINO

Affiliation: Battelle - Albuquerque

Education:
- M.E., Civil/Environmental Engineering, University of South Florida, 1994
- B.S., Mechanical Engineering, University of Pittsburgh, 1983

Technical Experience: Six years of experience in quality assurance, production engineering, and industrial hygiene and safety, and seven years of experience in environmental remediation.

EIS Responsibility: Technical Reviewer and contributed to the Comment and Response Document planning.

Name: MACHELE McKINLEY

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Environmental Engineering, Humboldt State University, 1992

Technical Experience: Three years of experience in computer modeling of saturated and unsaturated hydrology.

EIS Responsibility: Contributed to assessment of the post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: THOMAS McSWEENEY

Affiliation: Battelle - Columbus

Education:
- Ph.D., Chemical Engineering, University of Michigan, 1967
- M.A., Math, University of Michigan, 1964
- M.S., Chemical Engineering, University of Michigan, 1961
- B.S., Chemical Engineering, University of Notre Dame, 1960

Technical Experience: Twenty-eight years of experience in risk and safety analysis and ten years of experience in transportation risk analysis.

EIS Responsibility: Contributed to the transportation sections of Chapter 5 and Appendix E.

Name: TERRI B. MILEY

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Mathematics, University of South Carolina, 1986
- B.S., Mathematics, University of South Carolina, 1982

Technical Experience: Eight years of experience in performance assessment and groundwater risk assessments.

EIS Responsibility: Contributed to the performance assessment sections of Chapter 5 and Appendix H.

Name: MARK T. MURPHY

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Geology, Johns Hopkins University, 1989
- M.S., Geology, University of New Mexico, 1985
- B.S., Earth Science, University of California at Santa Cruz, 1977

Technical Experience: Eighteen years of experience in environmental geology and geological engineering.

EIS Responsibility: Contributed to the geology section of Chapter 4.

Name: ELIZABETH A. NAÑEZ

Affiliation: Battelle - Albuquerque

Education:
- B.S , Industrial Engineering, Texas Tech University, 1990

Technical Experience: Three years of experience in environmental engineering including one year of experience in NEPA document preparation.

EIS Responsibility: Contributed to sections of chapters 1, 3, 4, and 5, and compiled the list of preparers and contributors.

Name: IRAL C. NELSON

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.A., Physics, University of Oregon, 1955
- B.S., Mathematics, University of Oregon, 1951

Technical Experience: Forty years of experience in various aspects of health physics (radiation protection) and twenty-four years of experience in conducting NEPA reviews and preparing NEPA documentation. Diplomate, American Board of Health Physics, 1962.

EIS Responsibility: Co-preparer of Appendix B.

Name: WILLIAM E. NICHOLS

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Civil Engineering, Oregon State University, 1990
- B.S., Agricultural Engineering, Oregon State University, 1987

Technical Experience: Five years of experience in hydrologic and hydrothermal vadose zone modeling for performance assessment of waste isolation and disposal issues.

EIS Responsibility: Performed ground water transport modeling for the performance assessment sections of Chapter 5 and Appendix H.

Name: PAUL R. NICKENS

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Anthropology, University of Colorado, 1977
- M.A., Anthropology, University of Colorado, 1974
- B.A., Anthropology, University of Colorado, 1969

Technical Experience: Twenty-one years of experience in southwestern archaeology and cultural resource management, site protection and preservation.

EIS Responsibility: Prepared the cultural resources sections of chapters 4 and 5.

Name: TED M. POSTON

Affiliation: Battelle – Pacific Northwest National Laboratory

Education:
- M.S., Fisheries, Central Washington University, 1978
- B.S., Fisheries, Central Washington University, 1973

Technical Experience: Twenty years of experience in research, environmental assessment, and noise analysis.

EIS Responsibility: Performed the noise impact analyses for Chapter 5.

Name: RANDY F. REDDICK

Affiliation: Battelle – Albuquerque

Education:
- M.S., Environmental Health Engineering, University of Kansas, 1983
- B.S., Civil Engineering, University of Kansas, 1982

Technical Experience: Twelve years of experience with NEPA compliance, NEPA document preparation, and safety studies.

EIS Responsibility: Deputy Project Manager - Battelle - Albuquerque, technical support. Conducted technical and management reviews of the document.

Name: ROBERT A. ROOT

Affiliation: Battelle - Albuquerque

Education:
- Ph.D., Botany, Miami University, 1971
- M.S., Botany, University of Montana, 1968
- B.S., Botany, University of Maine, 1963

Technical Experience: Over twenty years of experience as an environmental scientist and project manager.

EIS Responsibility: Lead preparer of Chapter 3 and the Summary.

Name: STEVEN B. ROSS

Affiliation: Battelle - Albuquerque

Education:
- M.S., Nuclear Engineering, University of New Mexico, 1987
- B.S., Nuclear Engineering, University of New Mexico, 1985

Technical Experience: Ten years of experience in safety analysis, risk assessment, transportation, regulatory analysis, and fire risk assessment.

EIS Responsibility: Lead preparer of the transportation sections of chapters 4, 5, and Appendix E.

Name: KEITH D. SHIELDS

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Environmental Science, Washington State University - Tri-Cities, 1995
- B.S., Physics, Whitman College, 1989

Technical Experience: Six years of experience in environmental assessments and modeling.

EIS Responsibility: Contributed to the assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: SANDRA F. SNYDER

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S.P.H., Radiological Hygiene, University of North Carolina-Chapel Hill, 1991
- B.S., Environmental Resource Management, Pennsylvania State University, 1986

Technical Experience: Seven years of experience in environmental health physics risk assessment.

EIS Responsibility: Lead preparer, human health and facility accidents sections of Chapter 5 and appendices F and G.

Name: LISSA H. STAVEN

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Health Physics, Colorado State University, 1990
- B.S., Environmental Conservation, University of New Hampshire, 1984

Technical Experience: Six years of experience in environmental health physics.

EIS Responsibility: Contributed to the human health and facility accidents sections of Chapter 5, appendices F and G, and assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: GARY STREILE

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Soil Science (Soil Physics), University of California Riverside, 1984
- B.S., Physics, University of California Riverside, 1975

Technical Experience: Twenty years of experience in contaminant transport modeling and research into reactive contaminant transport processes.

EIS Responsibility: Contributed to the assessment of the post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: DENNIS L. STRENGE

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Chemical Engineering, University of Minnesota, 1968
- B.S., Chemical Engineering, University of Washington, 1966

Technical Experience: Twenty-seven years of experience in the fields of environmental health physics and risk assessment.

EIS Responsibility: Contributed to the assessment of post-institutional control period for No Action Alternative 2 in Chapter 5 and Appendix I.

Name: CARLOS A. ULIBARRÍ

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., Economics, University of New Mexico, 1992
- B.A., Economics and Spanish Literature, University of New Mexico, 1984

Technical Experience: Six years of experience in natural resource and environmental economics.

EIS Responsibility: Lead preparer of the socioeconomic sections of chapters 4 and 5 and Appendix D.

Name: LANCE W. VAIL

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- M.S., Civil Engineering, Montana State University, 1981
- B.S., Environmental Resources Engineering, Humboldt State University, 1980

Technical Experience: Fifteen years of experience in surface and subsurface hydrology.

EIS Responsibility: Contributed to the hydrology section of Chapter 4.

Name: JAMES R. WEBER

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- Ph.D., English, University of Oregon, 1983
- M.A., English, University of Oregon, 1981
- B.A., English and Philosophy, St. Olaf College, 1971

Technical Experience: Twelve years of experience as a Technical Communication Specialist and Trainer.

EIS Responsibility: Technical Editor.

Name: SANDRA K. WISE

Affiliation: Battelle - Albuquerque

Education:
- B.S., Environmental Health, Colorado State University, 1995

Technical Experience: Eight years of experience in data management, quality assurance and one year of experience in NEPA compliance.

EIS Responsibility: Prepared portions of Chapter 3, contributed to the preparation of the transportation sections of Chapter 5, and assisted in overall data collection.

Name: TOMMYE S. WRIGHT

Affiliation: Battelle - Pacific Northwest National Laboratory

Education:
- B.S., Health Physics, Oklahoma State University, 1978

Technical Experience: Seventeen years of experience in occupational safety and health physics. Certified Safety Professional (CSP) and member of the National Registry of Radiation Protection Technologists (NRRPT).

EIS Responsibility: Prepared the industrial health and safety sections of Chapter 5.

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