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EXECUTIVE SUMMARY

In 1989, the US Department of Energy (DOE) created the Office of Environmental Restoration and Waste Management (EM). The goal of this office is to implement the department's policy of ensuring that its past, present, and future operations do not threaten human health, safety, or the environment. The EM Office implements procedures to meet these goals through three associate directorates: Environmental Restoration (ER), Waste Operations, and Technology Development. The ER Program is responsible for assessing, cleaning up, decontaminating, and decommissioning sites at DOE facilities and at sites formerly used by DOE. This Installation Work Plan (IWP) describes how the DOE and the University of California (UC) will conduct the department's ER Program at Los Alamos National Laboratory (the Laboratory).

The Laboratory and the neighboring residential areas of Los Alamos and White Rock are located predominantly in Los Alamos County, north-central New Mexico, approximately 60 mi north-northeast of Albuquerque and 25 mi northwest of Santa Fe. The 43-mi^2 Laboratory site and the communities adjacent to it are situated on the Pajarito Plateau. The ephemeral and intermittent streams that drain the plateau have created numerous narrow finger-like mesas, whose tops range in elevation from approximately 7,800 ft on the flank of the Jemez Mountains to about 6,200 ft at their eastern termination above the Rio Grande valley. The eastern margin of the plateau stands 300 to 900 ft above the Rio Grande.

Since its inception in 1943, the Laboratory's primary mission has been nuclear weapons research and development. In the fall of 1992, in recognition of the end of the cold war and the ascendancy of non-defense-related problems both at home and abroad, the Laboratory's management announced a reorientation of Laboratory priorities. In September, the director introduced a revised mission statement for the Laboratory that reflects its new, expanded role:

> "Los Alamos National Laboratory is dedicated to developing world-class science and technology and applying them to the nation's security and well-being. The Laboratory will continue its special role in defense, particularly in nuclear weapons technology, and will increasingly use its multidisciplinary capabilities to solve problems in the civilian sector."

To this end, the Laboratory will, over the next 3-5 years, continue its defense programs as directed by Congress and will focus on developing new programs in three nationally significant areas for which it has special capabilities: health and biotechnology, environmental technologies, and industrial partnerships. Other Laboratory programs include applied photochemistry, astrophysics, earth sciences, lasers, computer sciences, energy resources (including solar and geothermal), and nuclear waste management research.

Since the early 1970s, the Laboratory has reported the results of an environmental surveillance program that routinely samples air, water, soil, and foodstuffs throughout the Los Alamos area to determine levels of contamination. The data collected under this program are published annually for distribution to the public and to local, state, and federal agencies. These data indicate that Laboratory operations do not currently threaten human health or the environment. The ER Program at the

Laboratory augments the environmental surveillance program by identifying potential future threats to human health and the environment and by mitigating them through efficient corrective actions that comply with applicable environmental regulations. Corrective actions include such measures as source containment to prevent contaminant migration, controls on future land use, and excavation and treatment of the source to remove hazards to health and the environment.

The ER Program at the Laboratory responds to two primary laws: the Resource Conservation and Recovery Act (RCRA), which is the statutory basis for the ER Program at the Laboratory, and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which provides a framework for remediating certain hazardous materials at the Laboratory that are not covered by RCRA. The hazardous waste provisions of RCRA govern the day-to-day operations of hazardous waste management, treatment, storage, and disposal (TSD) facilities. The law established a permitting system and set standards for all hazardous-waste-producing operations at a TSD facility. Under this law, the Laboratory qualifies as a treatment and storage facility and must have a permit to operate. In 1984, Congress amended RCRA by passing the Hazardous and Solid Waste Amendments (HWSA). Section 3004(u) of RCRA (as amended by HSWA) mandates that permits for TSD facilities include provisions for corrective action to mitigate releases from facilities currently in operation and to clean up contamination in areas designated as solid waste management units (SWMUs).

Congress conceived and passed CERCLA to clean up the nation's most hazardous abandoned waste sites. Under CERCLA, the Environmental Protection Agency (EPA) ranks abandoned facilties that have hazardous waste sites according to their potential threat to human health and the environment. The high-scoring sites are listed on the National Priorities List and are cleaned up in accordance with CERCLA regulations. The Laboratory has not yet been evaluated to determine whether it should be included on the National Priorities List.

DOE/UC's RCRA permit includes a section called the HSWA Module, which prescribes a specific corrective action program for the Laboratory and provides the primary guidance for the Laboratory's ER Program. This IWP has been prepared in accordance with the HSWA Module and with the corrective action requirements proposed for incorporation in EPA's standards for hazardous waste. EPA proposed Subpart S of 40 CFR 264 in July 1990 to implement the cleanup program mandated in Section 3004(u) of RCRA. This IWP describes how each of the following steps in the corrective action process will be implemented at the Laboratory.

- The RCRA facility investigation (RFI)—The goal of this step is to identify the nature and extent of contamination at sources and in environmental pathways that could lead to exposure of human and environmental receptors. This step is being implemented by characterizing the extent of contamination in the detail necessary to determine what corrective measures, if any, need to be taken. The Laboratory is answering only those questions relevant to deciding further actions.

- Corrective measures study (CMS)—If characterization indicates that corrective measures may be needed, this study will evaluate alternatives that might be reasonably implemented.

Corrective measures will be evaluated based on their projected efficacy in reducing risks to human and environmental health and safety in a cost-effective manner.

- Public hearings are part of the formal EPA review process. Additional public involvement is provided by the Laboratory's ER Program.

- Corrective measures implementation (CMI)—This step effects the chosen remedy, verifies its efficacy, and establishes ongoing control and monitoring requirements.

This IWP includes

- a program management plan that describes the organization and management of the Laboratory's ER Program, including projected schedules and costs;

- an overview of the ER Program's quality program plan, which integrates DOE Order 5700.6C, Quality Assurance, and QAMS 004180, Interim Guidelines and Specifications for Preparing Quality Assurance Programs, to ensure implementation of basic quality management requirements by the ER Program;

- a health and safety program plan that describes measures to ensure health and safety during implementation of the Laboratory's ER Program;

- a records management program plan that describes the mechanisms to be used to track information and data throughout the ER Program;

- a community relations program plan that describes how the Laboratory will provide information to and receive recommendations from the public throughout the life of the ER Program;

- a proposal to integrate RCRA closure and corrective action requirements; and

- a strategy for conducting interim remedial measures.

The HSWA Module defines the principal requirements with which DOE/UC must comply in implementing the ER Program at the Laboratory. However, RCRA does not address several issues of concern at Los Alamos. For example, source, byproduct, and special nuclear materials are exempt from RCRA's definition of solid waste and are therefore not subject to the provisions of the HSWA Module. DOE/UC recognize that these radioactive constituents are of concern and cannot be separated from concerns about hazardous wastes. Thus, DOE/UC's ER Program addresses radioactive as well as other hazardous substances not regulated by RCRA. This approach is intended to implement a technically comprehensive program that covers potential liabilities at sites that may contain hazardous substances regulated under CERCLA and radioactive materials regulated under the Atomic Energy Act; however, it is understood that language in this IWP pertaining to subjects outside the scope of RCRA is not enforceable under the RCRA permit.

The HSWA Module provides a schedule for addressing 603 SWMUs that the EPA has selected from potential release sites (PRSs) identified by DOE/UC. The schedule requires these units be addressed in RFI work plans by May 23, 1994, and that the CMS reports be complete by May 23, 2000. DOE/UC have aggregated into operable units all SWMUs to be taken through the corrective action process. Thus, the permit schedule for completing work plans will be met by submitting one RFI work plan for each of the 23 operable units that contain SWMUs.

DOE/UC propose to extend the RFI process by an amount that will delay completion of the CMS reports to the year 2002. This extension is necessary because the 603 SWMUs in the HSWA Module are only a subset of the approximately 2,000 PRSs that the ER Program must address to meet all applicable environmental regulations. In addition, the extended schedule allows the spread of effort over a period compatible with the availability of national resources, including funding.

Current risks from known PRSs are low; hence, at this time, no operable unit or set of PRSs has priority for action over others based on health or environmental concerns. The order in which operable units are being addressed has therefore been established to meet the annual percentages of completion specified by the HSWA Module. In addition, in response to requests from local property owners, the ER Program is giving priority to field work at former Laboratory locations in the townsite, which are no longer owned by the DOE.

In accordance with the provisions of the HSWA Module, this IWP is revised annually to reflect the current status of the ER Program at the Laboratory.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADS	Activity data sheet
AEA	Atomic Energy Act
AEC	US Atomic Energy Commission
ANSI	American National Standards Institute
ALARA	As low as reasonably achievable
AOC	Area of concern
AP	Administrative procedure
AR	Administrative requirement
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLS	Chemical and Laser Sciences (Division)
CMI	Corrective measures implementation
CMS	Corrective measures study
CRM	Communications and Records Management (Division)
D&D	Decontamination and decommissioning
DOE	US Department of Energy
DOE/AL	US Department of Energy /Albuquerque Operations Office
DOE/HQ	US Department of Energy /Headquarters
DP	Director's policy
DQO	Data quality objective
EES	Earth and Environmental Sciences (Division)
EETF	Experimental Engineered Test Facility
EIS	Environmental impact statement
EO	Executive order
EM	Environmental Management (Division)
EPA	US Environmental Protection Agency
ER	Environmental Restoration (Program)
FIMAD	Facility for Information Management, Analysis, and Display
FS	Feasibility study
FWS	Fish and Wildlife Service
FY	Fiscal year

GIS	Geographical Information System
HAZWOP	Hazardous Waste Operations Program
HAZWOPER	Hazardous Waste Operations and Emergency Response
H&S	Health and safety, Health and Safety (Division)
HE	High explosive(s)
HEAST	Health effects assessment summary table(s)
HSWA	Hazardous and Solid Waste Amendments
INC	Isotope and Nuclear Chemistry (Division)
IRIS	Integrated Risk Information System
IS	Information Services (Division)
ITP	Integrated test plot
IWP	Installation work plan
LAAO	Los Alamos Area Office (a branch of the Department of Energy)
LANL	Los Alamos National Laboratory
LASL	Los Alamos Scientific Laboratory (the Laboratory before January 1, 1981))
LLW	Low-level waste
MCL	Maximum contaminant level
MDA	Material disposal area
MSDWF	Mixed-Waste Storage and Disposal Facility
NEPA	National Environmental Policy Act
NFA	No further action
NMED	New Mexico Environment Department
NWI	National Wetlands Inventory
OSHA	Occupational Safety and Health Administration
OU	Operable unit
OUPL	Operable unit project leader
PCB	Polychlorinated biphenyl
PPL	Programmatic project leader
PRS	Potential release site
QA	Quality assurance
QAPjP	Quality assurance project plan
QC	Quality control
QP	Quality procedure
QPP	Quality program plan
R&D	Research and development

RFA	RCRA facility assessment
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RPF	Records-Processing Facility
SAL	Screening action level
SEN	Secretary of Energy notice
SOP	Standard operating procedure
SPPL	Senior programmatic project leader
SWMU	Solid waste management unit
TA	Technical area
TDR	Time domain reflectometry
TRU	Transuranic (waste)
TSD	Treatment, storage, disposal
TTL	Technical team leader
UC	University of California
USGS	US Geological Survey
VCA	Voluntary corrective action
VOC	Volatile organic compound
WBS	Work breakdown structure
WIPP	Waste Isolation Pilot Plant

1.0 INTRODUCTION

In 1989, the US Department of Energy (DOE) created the Office of Environmental Restoration and Waste Management (EM). The goal of this office is to implement the department's policy of ensuring that its past, present, and future operations do not threaten human or environmental health and safety (DOE 1991, 0549; DOE 1991, 0524). The EM Office implements procedures to meet these goals through three associate directorates: Environmental Restoration (ER), Waste Operations, and Technology Development. The ER Program is responsible for assessing, cleaning up, decontaminating, and decommissioning sites at DOE facilities and sites formerly used by DOE and its predecessors. As a facility operated by the DOE, Los Alamos National Laboratory (the Laboratory) is a part of this program.

The Laboratory is administered for the DOE by the University of California (UC). Historically, the principal mission of the Laboratory has been the design, development, and testing of weapons for the nation's nuclear arsenal. This effort is supported by research programs in nuclear physics, hydrodynamics, conventional explosives, chemistry, metallurgy, radiochemistry, and biology. In addition to the weapons program, Laboratory personnel are involved in medium-energy physics; space nuclear systems; controlled thermonuclear fusion; laser research; environmental research; geothermal, solar, and fossil energy research; nuclear safeguards; biomedical research; and space physics. Appendix A summarizes activities at the Laboratory's 49 active technical areas (TAs), which are shown in Figure 2-2.

In the fall of 1992, in recognition of the end of the cold war and the ascendancy of non-defense-related problems both at home and abroad, the Laboratory's management announced a reorientation of Laboratory priorities. In September, the director introduced a revised mission statement for the Laboratory that reflects its new, expanded role:

> "Los Alamos National Laboratory is dedicated to developing world-class science and technology and applying them to the nation's security and well-being. The Laboratory will continue its special role in defense, particularly in nuclear weapons technology, and will increasingly use its multidisciplinary capabilities to solve problems in the civilian sector."

To this end, the Laboratory will, over the next 3-5 years, continue its defense programs as directed by Congress and will focus on developing new programs in three nationally significant areas for which it has special capabilities: health and biotechnology, environmental technologies, and industrial partnerships. Other Laboratory programs include applied photochemistry, astrophysics, earth sciences, lasers, computer sciences, energy resources (including solar and geothermal), and nuclear waste management research.

Many of the processes used in carrying out the Laboratory's mission involve the use of hazardous and radioactive materials. During World War II and for a while thereafter, some of these materials were disposed on the Laboratory site or were otherwise released into the environment. Beginning in the 1970s, Congress enacted basic legislation to protect the environment. In that period also, the DOE and the Laboratory began to conduct surveys and to clean up areas where spills and casual disposal had occurred.

The current investigation being conducted at Los Alamos under the ER Program is intended to permit a definitive determination as to the presence or absence of

hazardous and radioactive wastes and to restore any sites where such materials are still found to exist. The ER Program at the Laboratory is committed to excellence In carrying out its responsibilities for investigating and remediating hazardous waste disposal sites. To accomplish this quality, the ER Program defines its mission as

> "bringing together multidisciplinary, world-class science, engineering, and state-of-the-art management practices to remedy environmental problems resulting from 50 years of Laboratory activity in Los Alamos by meeting both the letter and spirit of applicable environmental statutes and regulations. "

This updated Installation Work Plan (IWP) describes how the DOE and the University of California (UC) are conducting the DOE's ER Program at the Laboratory.

In 1980, Congress passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to clean up the nation's most hazardous abandoned waste sites. Under CERCLA, the Environmental Protection Agency (EPA) ranks abandoned facilities that have hazardous waste sites according to their potential threat to human health and the environment. The high-scoring sites are listed on the EPA's National Priorities List and are cleaned up in accordance with CERCLA regulations. The Laboratory has not yet been evaluated to determine whether it should be included on the National Priorities List.

Data for this determination included the results of the Laboratory's environmental surveillance program that routinely samples air, water, soil, and foodstuffs throughout the Los Alamos area to determine levels of contamination. The data collected under this program are published annually for distribution to the public and to local, state, and federal agencies. These data indicate that Laboratory operations do not currently threaten human health or the environment. The ER Program at the Laboratory augments the environmental surveillance program by identifying potential future threats to human health and the environment and by mitigating them through efficient corrective actions that comply with applicable environmental regulations. Corrective actions include such measures as source containment to prevent contaminant migration, controls on future land use, and excavation and treatment of the source to permanently eliminate hazards to health and the environment. The formal ER Program at the Laboratory took effect in 1990 through provisions of a permit issued by the EPA to the DOE/UC. The EPA retains oversight and approval authority for the program at Los Alamos.

The ER Program is regulated by the Resource Conservation and Recovery Act (RCRA). The hazardous waste management provisions of RCRA as enacted in 1976 govern the day-to-day operations of hazardous waste treatment, storage, and disposal (TSD) facilities. Sections 3004(u) and (v) of RCRA established a permitting system and set standards for all hazardous-waste-producing operations at a TSD facility. Under this law, the Laboratory qualifies as a treatment and storage facility and must have a permit to operate.

In 1984, Congress amended RCRA by passing the Hazardous and Solid Waste Amendments (HSWA). Sections 201, 202, 203, 206, 207, 212, 215, and 224 of HSWA modified the permitting sections of RCRA (Sections 3004 and 3005). In accordance with these provisions of HSWA, the Laboratory's permit to operate includes a section that prescribes a specific corrective action program for the Laboratory, which includes provisions for mitigating releases from facilities currently in operation and for cleaning up inactive sites. This portion of the permit is known as the HSWA Module.

The HSWA Module specifies a three-step corrective action process (Figure 1-1):

- The RCRA facility investigation (RFI)—The goal of this step is to identify the extent of contamination at the source and the environmental pathways along which contaminants could travel to human and environmental receptors. This step is being implemented by characterizing the extent of contamination in the detail necessary to determine what corrective measures, if any, need to be taken. This approach focuses on answering those questions relevant to deciding further actions in a cost-effective manner.

- Corrective measures study (CMS)—If characterization indicates that corrective measures are needed, this study will evaluate alternatives that might reasonably be implemented. These measures will be evaluated based on their projected efficacy in reducing risks to human and environmental health and safety in a cost-effective manner.

- Corrective measures implementation (CMI)—This step will implement the remedy chosen by the regulatory authority, verify its effectiveness, and establish ongoing control and monitoring requirements.

This IWP has been prepared to comply with the HSWA Module of the Laboratory's RCRA permit (EPA 1990, 0306). The major components of this IWP that address the requirements of the HSWA Module are shown in Table 1-1.

TABLE 1-1

REQUIREMENTS OF THE HSWA MODULE

Requirement	Location in IWP
Programmatic elements of the RCRA facility investigation (RFI) work plan	Chapter 3 and Annex I
Installationwide description of the current conditions of the Laboratory	Chapter 2
Tabular summaries of the Laboratory's potential release sites	Appendix F
RFI investigation work schedule	Annex I and Appendix N
Outlines for the task specific RI/FS documents	Chapter 3
Installationwide overview of the hydro-geological environment of the Laboratory	Chapter 2
Project Management Plan	Annex I
Data Collection Quality Assurance Plan	Annex II
Data Management Plan	Annex IV
Health and Safety Plan	Annex III
Community Relations Plan	Annex V
Waste Minimization Plan	Appendix B

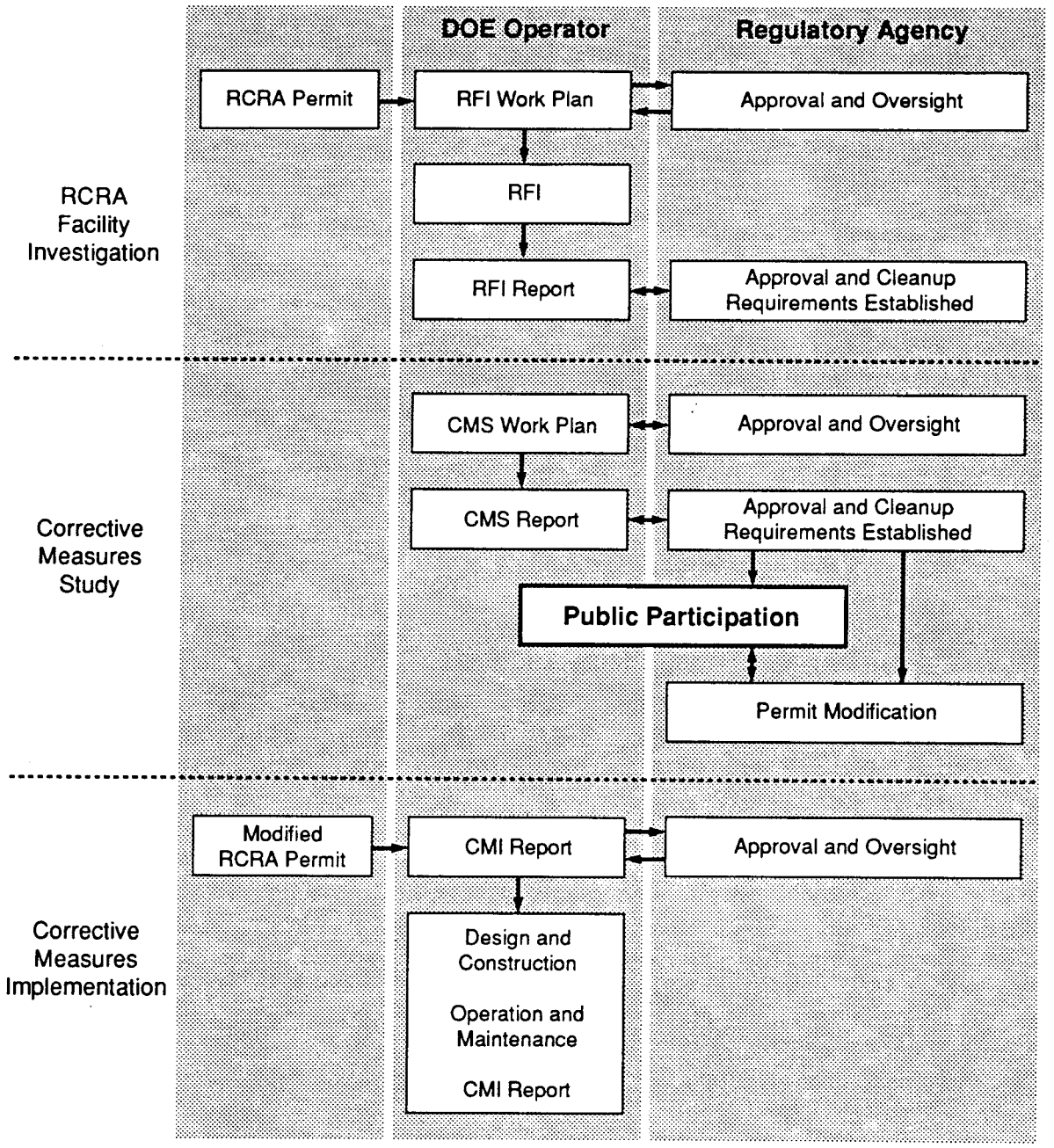

Figure 1-1. RCRA corrective action process at the Laboratory.

The fundamental unit to which these requirements apply is the solid waste management unit (SWMU), defined by EPA in the HSWA Module as

> "...any discernible unit at which solid wastes have been placed at any time, irrespective of whether it was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released."

The HSWA Module defines the principal requirements with which DOE/UC must comply in implementing the ER Program at the Laboratory. However, RCRA does not address several issues of concern at Los Alamos. For example, source, by-product, and special nuclear materials (defined in the Atomic Energy Act) are exempt from RCRA's definition of solid waste and are therefore not subject to the provisions of the HSWA Module. DOE/UC recognize that these radioactive constituents are of concern and cannot be separated from concerns about hazardous wastes. Thus, DOE/UC's ER Program addresses radioactive as well as other hazardous substances not regulated by RCRA. The sites that contain potentially hazardous materials but no hazardous substances defined by RCRA are called areas of concern (AOCs). In this document, SWMUs and AOCs are collectively referred to as "potential release sites" (PRSs). This approach is intended to implement a technically comprehensive program that covers potential liabilities at sites that may contain hazardous substances regulated under CERCLA and radioactive materials regulated under the Atomic Energy Act; however, it is understood that language in this IWP pertaining to subjects outside the scope of RCRA is not enforceable under the RCRA permit.

DOE/UC are using the operable unit (OU) approach defined in CERCLA for organizing and managing the various PRSs. OUs are aggregates of PRSs that will be addressed together. The details for each step required under the corrective action process will be presented individually for each OU.

The HSWA Module provides a schedule for addressing 603 SWMUs that the EPA has selected from PRSs identified by DOE/UC. The schedule requires that these units be addressed in RFI work plans by May 23, 1994, and that any CMS reports that are necessary be completed by May 23, 2000. The permit schedule for completing work plans will be met by submitting one RFI work plan for each of the 23 operable units that contain SWMUs. An additional requirement of the permit is that a subset of the 603 SWMUs, consisting of 187 SWMUs, were to be addressed by work plans submitted by May 23, 1993. The aggregation of SWMUs in work plans is such that the 187 priority SWMUs will be addressed as required by the permit.

DOE/UC propose to extend the RFI process by an amount that will delay completion of the last CMS reports to the year 2002. This extension is necessary because the 603 SWMUs in the HSWA Module are only a subset of the approximately 2,000 PRSs that the ER Program must address to meet all applicable environmental regulations. In addition, the extended schedule allows the spread of effort over a period compatible with the availability of national resources, including funding.

Current risks from known PRSs are low; hence, at this time, no OU or set of PRSs has priority for action over others based on health or environmental concerns. The order in which OUs are being addressed has therefore been established to meet the annual percentages of completion specified by the HSWA Module. In addition, in response to requests from local property owners, the ER Program is giving priority to field work at former Laboratory locations in the townsite, which are no longer

owned by the DOE. The program is designed to identify sites for no further action or cleanup under EPA's provisions for voluntary corrective action as early in the process as possible.

This program will be conducted to meet the requirements of applicable DOE environmental orders, including 5400.1, General Environmental Protection Program; 5400.3, Hazardous and Radioactive Mixed Waste Program; 5400.4, Comprehensive Environmental Response, Compensation, and Liability Act Requirements; 5400.5, Radiation Protection of the Public and the Environment; and 5400.2A, Environmental Compliance Issue Coordination. Additional DOE orders that are incorporated in this program are listed in Annex I.

This IWP provides generic information about the ER Program at the Laboratory; thus, each RFI work plan need discuss only information specific to individual OUs. Chapter 2 of this document contains a description of the environmental setting and a brief history of the Laboratory. Chapter 3 describes the regulatory framework and structure of the ER Program, including the addition in 1992 of the Laboratory's Decontamination and Decommissioning Program to the ER Program. Chapter 4, which is new in this version of the IWP, describes the technical approach used throughout the ER Program at the Laboratory.

This document contains five annexes consisting of plans required by the HSWA Module: the Program Management Plan, an overview of the ER Program's Quality Assurance Program, the Health and Safety Program Plan, the Records Management Program Plan, and the Community Relations Program Plan. In addition, it contains several appendices that supplement, as needed, information provided in Chapters 1-4 and the annexes. The appendices are followed by a list of contributors, a glossary, and a table showing conversion of metric to English units of measure.

In accordance with the provisions of the HSWA Module, this plan is revised annually to reflect the current status of the ER Program at the Laboratory, future plans, and near- and long-term schedules. This document is the second revision.

References for Chapter 1

DOE (US Department of Energy), August 1991, "Five-Year Plan: Fiscal Years 1993-1997," National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. (DOE 1991, 0549)

DOE (US Department of Energy), August 1991. "Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1993-1997," DOE/S-0089P, Office of Environmental Restoration and Waste Management, Washington, DC. (DOE 1991, 0524)

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, 0306)

2.0 INSTALLATION DESCRIPTION

2.1 Geographic Setting

Los Alamos National Laboratory (the Laboratory) and the neighboring residential areas of Los Alamos and White Rock are located predominantly in Los Alamos County, north-central New Mexico, approximately 60 mi north-northeast of Albuquerque and 25 mi northwest of Santa Fe (Figure 2-1). The 43-mi^2 Laboratory site and the communities adjacent to it are situated on the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons containing ephemeral and intermittent streams that run from west to east. Mesa tops range in elevation from approximately 7,800 ft on the flank of the Jemez Mountains to about 6,200 ft at their eastern termination above the Rio Grande valley. The eastern margin of the plateau stands 300 to 900 ft above the Rio Grande (DOE 1979, 0051). The Department of Energy (DOE) controls the area within the Laboratory's boundaries and has the option of completely restricting access.

2.2 Mission of Los Alamos National Laboratory

The Laboratory is administered for the DOE by the University of California (UC). Since its inception in 1943, the principal mission of the Laboratory has been the design, development, and testing of weapons for the nation's nuclear arsenal. This effort is supported by research programs in nuclear physics, hydrodynamics, conventional explosives, chemistry, metallurgy, radiochemistry, and biology. In addition to the weapons program, Laboratory personnel are involved in medium-energy physics; space nuclear systems; controlled thermonuclear fusion; laser research; environmental research; geothermal, solar, and fossil energy research; nuclear safeguards; biomedical research; and space physics. Appendix A summarizes activities at the Laboratory's 49 active technical areas (TAs), which are shown in Figure 2-2.

In August 1977, the Laboratory site was dedicated as a National Environmental Research Park. The ultimate goal of programs associated with this research facility is to encourage environmental research that will contribute understanding of how people can best live in balance with nature while enjoying the benefits of technology. Park resources are available to individuals and organizations outside the Laboratory to facilitate self-supported research on these subjects.

In 1992, the Laboratory expanded its mission to include development of new programs in three nationally significant areas for which it has special capabilities: health and biotechnology, environmental technologies, and industrial partnerships.

2.3 History of Los Alamos National Laboratory

In 1942, the US Army Manhattan Engineer District was established to develop the atomic bomb. The research quickly progressed to a point that necessitated a remote site for experimental work, and the Army selected the Los Alamos Ranch School for Boys as an appropriate location. The Undersecretary of War directed acquisition of the school site, which consisted of a group of some 50 log buildings on a 790-acre site northwest of Santa Fe. The project ultimately acquired an additional 3,120

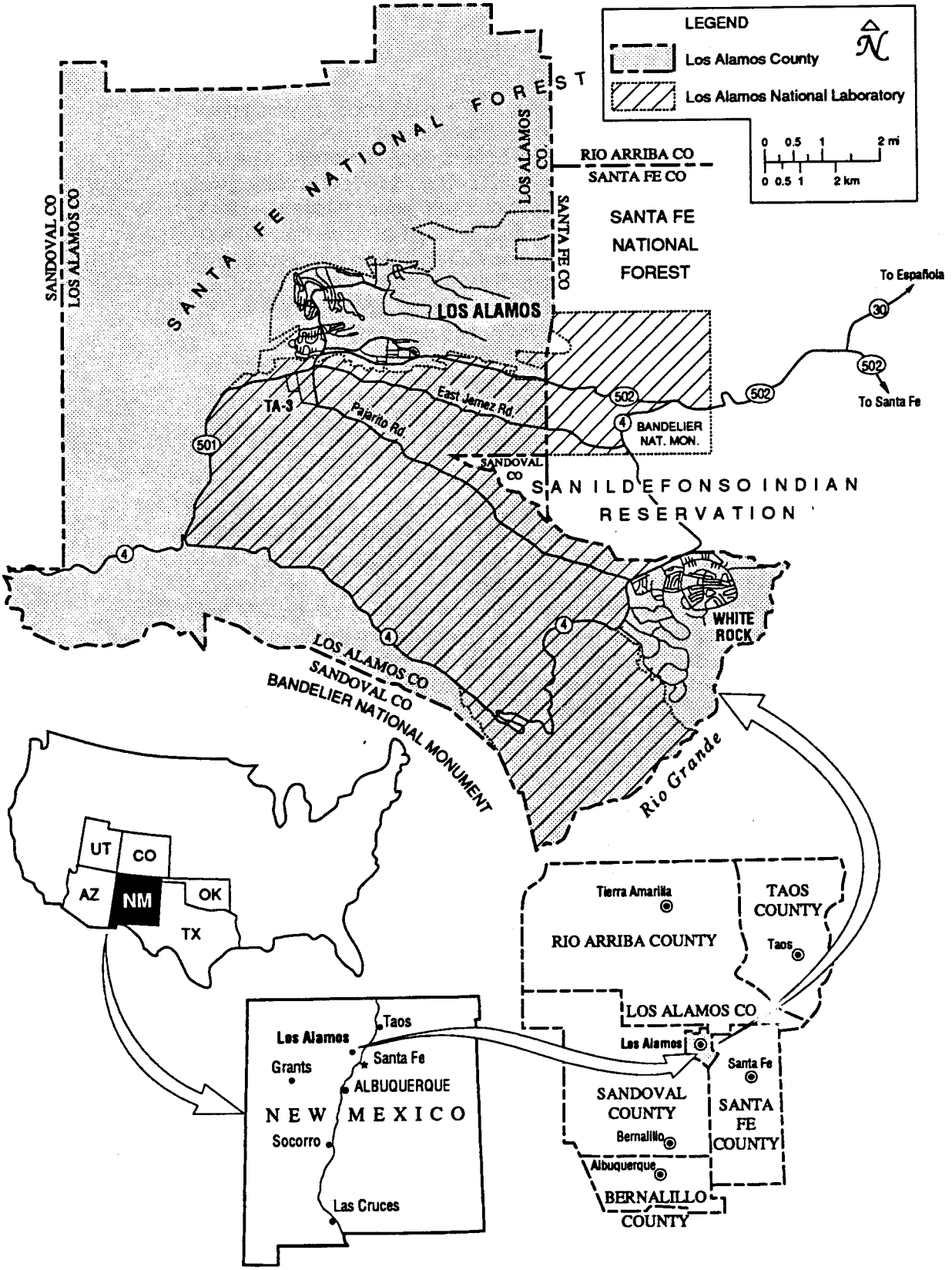

Figure 2-1. Location map of Los Alamos National Laboratory.

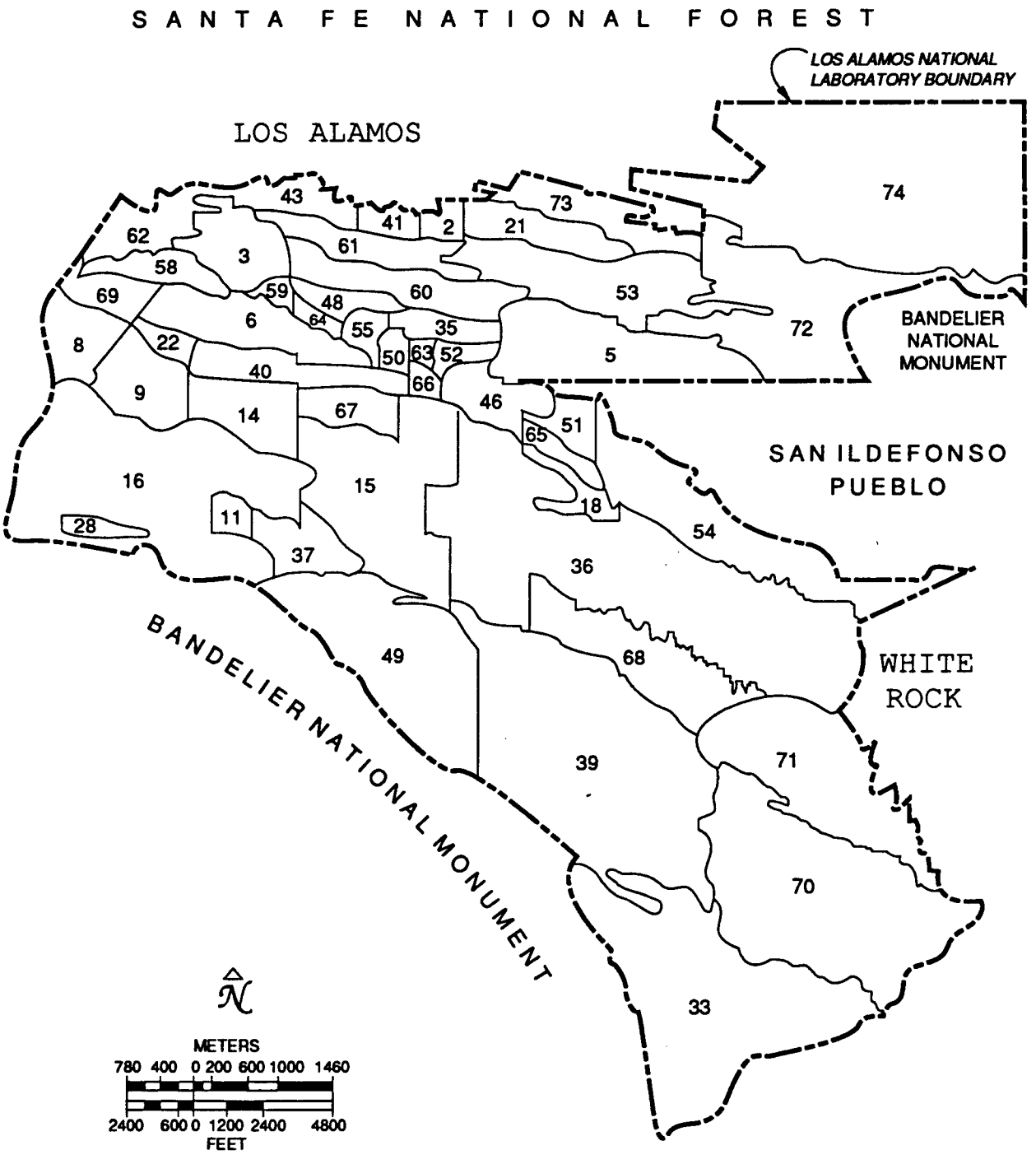

Figure 2-2. Technical areas at Los Alamos National Laboratory.

privately owned acres and 45,666 acres of public land managed by the US Forest Service. In 1943, this land became known as the Los Alamos Site, later Los Alamos Scientific Laboratory.

Since its inception, UC has operated the Laboratory for the federal government. Research activities were established in wooden buildings south of the original Ranch School buildings in what is now downtown Los Alamos. Additional Laboratory buildings were constructed; army-style barracks, temporary and prefabricated, provided housing.

With the end of World War II and the growth of international competition, a national policy of maintaining superiority in the field of atomic energy was established. Congress chose to sustain the Los Alamos site; the Atomic Energy Commission (AEC) received control of the Laboratory from the Army and renewed the operating contract with UC. Thereafter, a major construction program was started south of Los Alamos Canyon. During subsequent years, the Laboratory continued to expand at a steady rate, first under the AEC and later under the Energy Research and Development Administration. Since 1978, the Laboratory has operated under the control of the DOE and is currently officially known as Los Alamos National Laboratory.

2.4 Waste Management Practices

Activities at the Laboratory have generated and will continue to generate three types of hazardous wastes: (1) wastes from processing operations, (2) wastes from research and development (R&D) activities, and (3) high-explosive waste. These three main groups of hazardous wastes result from processing effluents, separating isotopes, manufacturing, conducting R&D programs in basic and applied chemistry, testing and manufacturing explosives, cleaning chemically contaminated equipment, and processing radioactive materials. Table 2-1 lists the hazardous wastes generated at Los Alamos, which are categorized by generation process.

Since 1972, the Waste Management Group (EM-7) has prepared waste management site plans annually. These plans identify and describe the areas and processes that generate significant radioactive and hazardous wastes. Treatment facilities, material disposal areas (MDAs), and storage facilities are also described, as are the volumes of waste treated during the year and the alpha activity of radioactive waste and effluents. The plans also describe decontamination and decommissioning and future waste management plans and budgets. The Laboratory is required to minimize the waste its processes generate. The plan for meeting this requirement is included as Appendix B.

To accommodate wastes generated during the course of the corrective action process, the ER Program proposes to construct a Mixed-Waste Storage and Disposal Facility (MWSDF). This facility will operate under the appropriate federal and state permits and will meet all relevant federal and state pollution control requirements.

TABLE 2-1

Hazardous Wastes at Los Alamos Identified by Generation Process and Waste Characterization

Process or Operation Generating Hazardous Wastes	Wastes Generated	Approximate Annual Volume (lb)	Hazard Code	EPA Hazardous Waste Number[a]
Basic and Applied Chemistry R&D Program				
Chemistry and Metallurgy Research Building Radiochemistry Laboratory Health Research Laboratory	Numerous chemical wastes	Organic 50,000 Inorganic 40,000	Varies	Many
Electrochemistry Processing				
Materials Technology Group	Cyanide and chromate plating solutions	2,000	Toxic, reactive	F007, F009
Printed Circuit Board Shop	Acid/base copper etching/plating solutions	40,000	Corrosive	D002
Isotope Separation				
Isotope and Structural Chemistry Group	Concentrated nitric and sulfuric acid	80,000	Corrosive	D001, D002
Shops (Mechanical Fabrication Division)				
	Lithium hydride, lithium metal	3,500	Reactive	D003
	Halogenated solvents	<1,000	Toxic	F001, F002
	Nonhalogenated solvents	<1,000	Ignitable	F003
Explosives				
Dynamics Testing and Design Engineering	High explosives, potential for barium	50,000	Ignitable, reactive	D001, D003, D005, and K044
	Contaminated burn pad sand	10,000	TCLP[b] toxic	D005
Chemically Contaminated Equipment				
LANL Facilities	Empty drums, tanks, cylinders, etc.	12,000	Varies	Many

a. 40 CFR Part 261, Identification and Listing of Hazardous Wastes.

b. Toxicity characteristic leaching procedure.

2.5 Overview of the Environmental Setting

2.5.1 Land Use Patterns

Most Laboratory and community developments are confined to mesa tops. Large tracts of land north, west, and south of the Laboratory site are managed by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County (Figure 2-3). The San Ildefonso Pueblo borders Los Alamos County to the east.

Laboratory land is used for building sites, experimental areas, waste disposal locations, roads, and utility rights-of-way. However, these uses account for only a small part of the land. Most of the land controlled by the Laboratory serves as a buffer zone for Laboratory facilities, providing security and safety, and as a reserve for future construction. The Laboratory's long-range site development plan (Pava 1990, 0368) ensures adequate planning for the best possible future uses of available Laboratory lands.

The public is allowed limited access to certain areas of the Laboratory site. An area north of Ancho Canyon between the Rio Grande and State Road 4 is open to hikers, boaters, and hunters, but woodcutting and vehicles are prohibited. Portions of Mortandad and Pueblo canyons are also open to the public. An archaeological site (the Otowi tract), northwest of State Road 502 near the White Rock Y, is open to the public, subject to restrictions imposed by regulations to protect cultural resources.

2.5.2 Ecology

Understanding of the structural and functional relationships among Los Alamos area ecosystems is limited, partly because of the wide diversity of ecosystems. This diversity has been created by the pronounced 4,920-ft elevation gradient that extends from the Rio Grande on the east to the Jemez Mountains 12 mi to the west. Many canyons, with abrupt changes in surface slope, parallel this gradient. The pronounced east-west canyon and mesa orientations, with concomitant differences in soils, moisture, and solar radiation, produce an interlocking finger effect among ecological life zones, resulting in many transitional overlaps of plant and animal communities within small areas. Maps of the topography, wetlands, and flood plains at Los Alamos are contained in Appendix C. Section 2.6 provides a detailed overview of the hydrogeological environment at Los Alamos.

2.5.2.1 Flora

Six major vegetative complexes (community types) are found in Los Alamos County. A piñon-juniper forest surrounds most of the Laboratory. Within the confines of the Laboratory's border, the predominant community types are ponderosa pine woodland (6,900 to 7,500 ft in the western third of the reservation), piñon-juniper (6,200 to 6,900 ft in the central third), and juniper-grassland (5,600 to 6,200 ft in the eastern third). Most of the environmental surveillance, waste operations, and R&D activities affect physical, chemical, and biological components of the piñon-juniper woodland.

Less is known about ecosystems other than the piñon-juniper woodland. Hakonson et al. (1973, 0118) provide a general description of the Laboratory and environs.

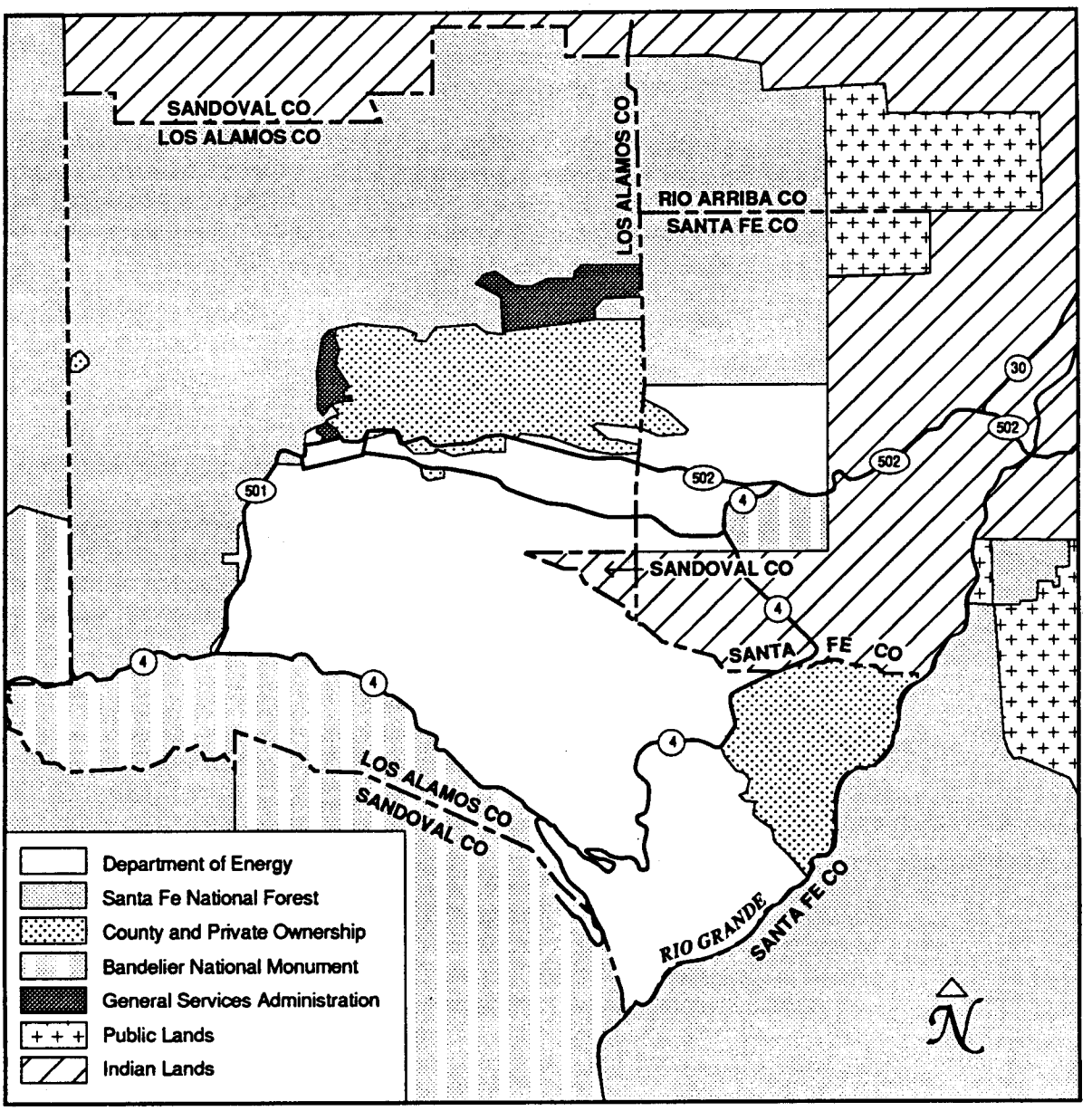

Figure 2-3. Land ownership in the Los Alamos area.

Almost 350 plant species have been identified, and species lists have been prepared (DOE 1979, 0051). Special studies have described the past and current status of the flora of the complex (Foxx and Tierney 1980, 0101; 1984, 0102; 1985, 0103). Past and present uses of the Laboratory and adjacent lands have resulted in structural changes in plant communities. Laboratory uses have had, and will continue to have, important consequences for local ecosystems. Few construction and waste disposal activities have occurred in the flood plains of canyons in and near the Laboratory. Natural wetland areas occur in some canyons, and more extensive wetlands have developed as a result of effluent outfalls.

The grama grass cactus, which is proposed for inclusion in the federal endangered species list, has been found on the dry mesa tops of Los Alamos County at elevations of about 6,000 to 6,400 ft. However, it has not been found on Laboratory property. Penalties exist for transporting plants protected under the 1985 New Mexico Rule No. NRD:85-3. Among the species protected under this rule, nine have been documented in the vicinity of Los Alamos County. To date, none has been found on Laboratory property.

2.5.2.2 Fauna

Before the Laboratory was established, Native Americans and European settlers farmed the mesas, disturbing areas that are now in various stages of succession. These areas afford suitable feeding locations for herbivores, especially deer and elk, and adjacent timbered canyon slopes provide cover for these species. Sheer canyon walls at lower elevations serve as important nesting habitats for birds of prey. Generally, larger mammals, reptiles, and invertebrates are most sensitive to variations in elevations and are confined to smaller ranges.

Information on the fauna within the Laboratory complex is largely qualitative. Species lists have been compiled from observational data and published data (DOE 1979, 0051), but the occurrence of some species has not been verified. Only one limited fauna survey has been conducted on Laboratory grounds (Miera et al. 1977, 0148). Special studies are currently under way to provide a more comprehensive survey of vertebrate fauna.

Based on published reports and ongoing surveys, one federally listed endangered animal species, the peregrine falcon, is known to inhabit Los Alamos County. A peregrine aerie exists in Pueblo Canyon. The nesting peregrines from this aerie, as well as other raptors, hunt on Laboratory lands; however, no critical habitats have been defined. The Jemez Mountain salamander has been found in the moist upper reaches (above 8,000 ft) of the canyons that dissect the plateau, usually at an elevation higher than that of the Laboratory. In 1985, one specimen was collected and recorded as having been found on Laboratory property. This species is listed as endangered by the state and federal governments.

2.5.3 Climate

Bowen (1990, 0033) has compiled and interpreted climatological data for the Los Alamos area, and this information is summarized below.

Los Alamos has a semiarid, temperate mountain climate. Forty percent of the 18-in. annual precipitation normally occurs from thundershowers during July and

August. Winter precipitation falls primarily as snow, with accumulations of about 51 in. annually.

Summers are generally sunny, with moderate, warm days and cool nights. Maximum daily temperatures are usually below 90°F. Brief afternoon and evening thundershowers are common, especially in July and August. High altitude, light winds, clear skies, and dry atmosphere allow night temperatures to drop to the 50s (°F) after even the warmest day. Winter temperatures typically range from about 15°F to 25°F during the night and from 30°F to 50°F during the day. Occasionally, temperatures drop to 0°F or below. Many winter days are clear with light winds, allowing strong sunshine to make conditions comfortable even when air temperatures are cold. Snowstorms with accumulations exceeding 4 in. are common in Los Alamos, and some of these storms are associated with strong winds, frigid air, and dangerous wind chills, especially in the mountains.

The climate from 1961 through 1988 had slightly cooler temperatures and higher precipitation than those recorded from 1911 through 1988 (entire record). The only significant difference between the period between 1961 and 1988 and the entire record period is the large amount of snowfall.

Because of complex terrain, surface winds in Los Alamos often vary greatly with time of day and location. With light winds and clear skies, a distinct daily wind cycle often exists: a light southeasterly to southerly upslope wind during the day and a light westerly to northwesterly drainage wind during the night. However, several miles to the east toward the edge of Pajarito Plateau near the Rio Grande valley, a different daily wind cycle is common: a moderate southwesterly up-valley wind during the day and either a light northwesterly to northerly drainage wind or moderate southwesterly wind at night. The predominant winds are southerly to northwesterly over western Los Alamos County and southwesterly and northeasterly toward the Rio Grande valley.

Historically, no tornadoes have been reported to have touched down in Los Alamos County. Strong dust devils can produce winds up to 75 mph at isolated spots in the county, especially at lower elevations. Strong winds with gusts exceeding 60 mph are common during the spring.

Lightning is common over the Pajarito Plateau. Fifty-eight thunderstorm days occur during an average year, mostly during the summer. Lightning protection is an important design factor for most facilities at the Laboratory. Hail damage can also occur. Hailstones with diameters up to 0.25 in. are common; 0.5-in.-diameter hailstones are infrequent.

The irregular terrain at Los Alamos affects atmospheric turbulence and dispersion, sometimes favorably and sometimes unfavorably. Enhanced dispersion promotes greater dilution of contaminants released into the atmosphere. The complex terrain and forests create an aerodynamically rough surface, forcing increased horizontal and vertical dispersion. Dispersion generally decreases at lower elevations, where the terrain becomes smoother and less vegetated. The frequent clear skies and light, large-scale winds cause good vertical daytime dispersion, especially during the warm season. Strong daytime heating during the summer can force vertical mixing up to 3,000 to 6,000 ft above ground level, but the effectiveness of the generally light winds in diluting contaminants horizontally is limited.

Clear skies and light winds have a negative effect on nighttime dispersion, causing strong, shallow surface inversions to form. These inversions can severely restrict

near-surface vertical and horizontal dispersion. Inversions are especially strong during the winter. Drainage winds can fill lower areas with cold air, thereby creating deeper inversions, which are common toward the Rio Grande valley on clear nights with light winds. Canyons can also limit dispersion by channeling air flow. Strong, large-scale inversions during the winter can limit vertical mixing to under 3,000 ft above ground level.

Dispersion is generally greatest during the spring, when winds are strongest. However, deep vertical mixing is greatest during the summer. Dispersion is generally low during summer and autumn, when winds are light. Even though low-level winter dispersion is generally greater, intense surface inversions can cause least-dispersive conditions during the night and early morning.

During the winter, the frequencies of atmospheric dispersive capability (sampled at TA-59) are 52% unstable (Stability Classes A through C), 21% neutral (Class D), and 27% stable (Classes E and F). The frequencies are 44%, 22%, and 34%, respectively, during the summer. These stability category frequencies are based on measured vertical wind variations. Stability generally increases (the winds become less dispersive) toward the valley.

2.5.4 Population Distribution

Los Alamos County had an estimated 1989 population of approximately 19,300 (based on the 1980 census adjusted for 1989). Two residential areas (Los Alamos and White Rock) and their related commercial areas exist in the county (Figure 2-1). The Los Alamos townsite (the original area of development that now includes residential areas known as Eastern Area, Western Area, North Community, Barranca Mesa, and North Mesa) has an estimated population of 12,100. The White Rock area (including the residential areas of White Rock, La Senda, and Pajarito Acres) has about 7,200 residents. About one-third of the people employed in Los Alamos commute from other counties. Population estimates for 1990 place about 208,000 persons within a 50-mi radius of Los Alamos (Table 2-2).

2.6 Geologic and Hydrologic Setting

This overview of the hydrogeologic environment at the Laboratory and in the northern New Mexico region is intended to describe the major geologic, hydrologic, and hydrogeologic features and their conceptual interrelationships. It addresses the regional and installation-wide geologic setting and the hydrologic characteristics that affect surface water and groundwater occurrence and movement and their interactions as they relate to the potential for contaminant transport. This overview is intended as a guide to the significant literature in these areas rather than as a technical summary. The sources cited here and additional literature on the hydrology and geology of the Los Alamos region may be found in an annotated bibliography of geologic, hydrogeologic, and environmental studies related to solid waste management units at the Laboratory LANL (1990, 0143). This bibliography was submitted to EPA in September 1990, and it and the literature it describes are available for review in the ER Program's public reading room located at 2111 Trinity Drive, Building 2, Room 10, in Los Alamos.

TABLE 2-2
1990 POPULATION WITHIN 80 KM OF LOS ALAMOS

	Distance from TA-53 (km)								
Direction	1 – 2	2 – 4	4 – 8	8 – 15	15 – 20	20 – 30	30 – 40	40 – 60	60 – 80
N	1	0	0	0	0	0	1,136	0	368
NNE	0	0	0	565	0	542	1,730	1,797	221
NE	1	0	0	0	317	15,352	1,009	1,135	3,846
ENE	0	0	0	1,940	1,563	2,716	2,729	1,187	2,214
E	0	0	83	25	556	1,145	696	0	1,402
ESE	0	0	0	0	0	293	23,151	1,067	1,476
SE	0	0	6,757	0	0	0	53,520	2,443	8
SSE	0	0	0	0	0	0	426	4,347	95
S	0	0	0	50	0	318	614	6,775	0
SSW	0	0	0	20	0	817	201	8,238	33,485
SW	0	0	0	0	0	0	315	4,157	0
WSW	0	0	0	0	0	315	313	2,545	207
W	0	0	0	0	0	0	0	164	132
WNW	0	1,435	6,535	0	0	0	0	0	3,081
NW	0	523	1,721	0	0	0	0	1,438	0
NNW	0	578	579	0	0	0	0	64	62
1990 Population Distribution	2	2,536	15,675	2,600	2,436	21,497	85,838	35,357	46,597

Total population within 80 km of Los Alamos is 213,000.

2.6.1 Geology

2.6.1.1 Regional Setting

The Laboratory is situated on the Pajarito Plateau on the east flank of the Jemez Mountains and on the west side of the Rio Grande valley (Figure 2-4). The Jemez Mountains are part of the Jemez volcanic field, which consists of some 432 mi^3 of volcanic rocks erupted from numerous vents, including a giant, multistage caldera (Gardner et al. 1986, 0310). The Jemez volcanic field occurs at the intersection of the Jemez lineament, a northeast-trending alignment of volcanic fields, and the Rio Grande rift, a major north-trending zone of extensional tectonics (Aldrich 1986, 0554).

Two major volcanic eruptions in the Jemez Mountains that occurred about 1.5 and 1.13 million years ago produced widespread and voluminous ash flow sheets: the Otowi and Tshirege members of the Bandelier Tuff (Smith and Bailey 1966, 0377; Spell et al. 1990, 0607). The morphology of the Pajarito Plateau is dominated by a gently eastward-sloping surface, formed on top of the Bandelier Tuff, which is dissected by numerous steep-sided canyons. The Otowi and Tshirege Members of the Bandelier Tuff were erupted concomitantly with the collapse of the Toledo and Valles calderas, respectively. Following formation of the calderas, volcanism continued with the extrusion of domes along ring fractures. The latest eruption in the Jemez Mountains occurred about 130,000 years ago, producing the El Cajete

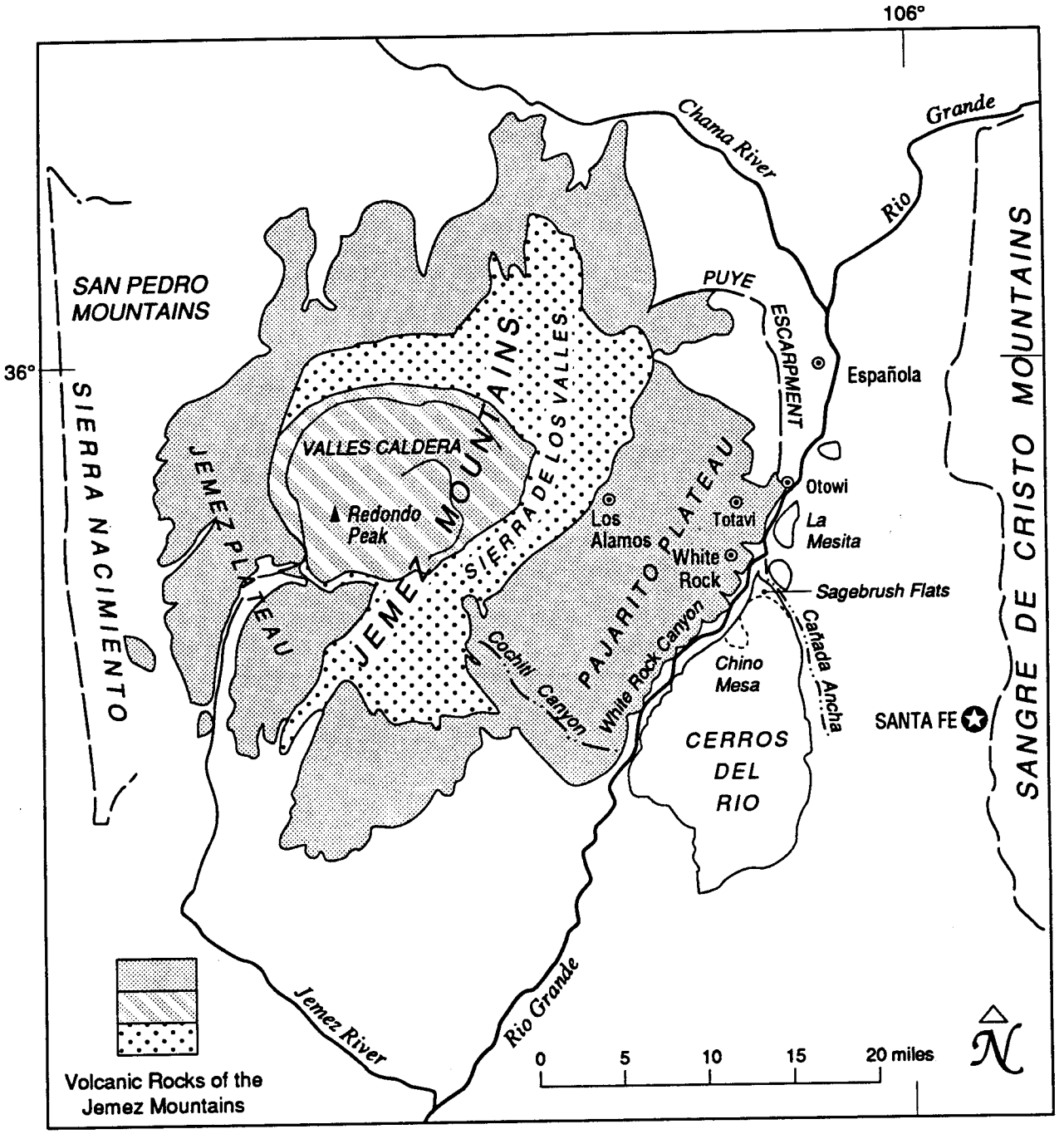

Figure 2-4. General geographic location map showing topographic features in the vicinity of Los Alamos.

pumice and Banco Bonito rhyolite flow (Gardner et al. 1986, 0310; Self et al. 1988, 0500). Vestiges of volcanic activity continue today, as evidenced by solfataric and hot spring activity both within and outside of the Valles caldera (Goff et al. 1989, 0774). Studies of P-wave arrival time delays suggest the presence of partially molten rock beneath the Valles caldera, possibly the remnants of the cooling Bandelier magma chamber (Roberts et al. 1991, 0775).

The Pajarito Plateau is in the western part of the Española basin of the Rio Grande rift, a major tectonic feature of the western United States. The Española basin lacks distinct major faults on its eastern margin, but faults of major vertical offset may exist within Precambrian rocks of the Sangre de Cristo uplift (Vernon and Riecker 1989, 0558; Biehler et al. 1991, 0528). The western margin is characterized by a prominent zone of major faults, which cuts Miocene to Quaternary rocks of the Jemez volcanic field (Smith et al. 1970, 0776; Gardner and Goff 1984, 0719; Goff et al. 1990, 0557). These border faults exerted strong control on the location and development of the volcanic field (Gardner and Goff 1984, 0719; Gardner et al. 1986, 0310).

Rocks formed before the rift developed are exposed around the margins of and underlie the Española basin. These rocks consist of Mississippian to Permian marine limestones, sandstones, and shales; Mesozoic marine to terrestrial sandstones and shales; and Eocene sandstones, shales, and freshwater limestones. Precambrian rocks—predominantly quartzite, granitic gneiss and schist, and greenstone—are exposed in the cores of the flanking Sangre de Cristo, Nacimiento, and Brazos uplifts (Kelley 1978, 0641). The earliest sediments deposited in the Tertiary Española basin are those of the Abiquiu, Picurís, and Los Piños formations, which consist of tuffaceous sandstones and volcaniclastic conglomerates derived largely from volcanic highlands to the north and northeast. These units range in age from about 28 to 17 million years old (Baldridge et al. 1980, 0527; May 1984, 0536; Ingersoll et al. 1990, 0533).

2.6.1.2 Stratigraphic Units

Beneath a veneer of soils and alluvial deposits, the mesas of the Pajarito Plateau are immediately underlain by the Bandelier Tuff of Pleistocene age, which is exposed in the canyon walls and is penetrated by numerous drill holes. Beneath the Bandelier Tuff, a sequence of interstratified sedimentary and volcanic rocks of Miocene to Pleistocene age occur, which have been penetrated by water supply wells and which have been studied where they outcrop in canyons on the margins of the Pajarito Plateau. These rock units include volcanic rocks of the Paliza Canyon Formation, Tschicoma Formation, and the Cerros del Rio volcanic field, and sedimentary deposits of the Puye Formation, the Totavi Formation, the Cochiti Formation and the Santa Fe Group. These units are briefly discussed below.

2.6.1.2.1 Santa Fe Group

The Santa Fe Group of Miocene and early Pliocene age (formed 18 to 4.5 million years ago) is a thick series of terrestrial conglomerates, sandstones, and mudstones, with minor limestones, evaporites, volcanic tuffs, and intercalated basalts. These rocks are the most extensive units filling the Rio Grande rift, and most production from water wells at Los Alamos is from the Santa Fe Group (Griggs and Hem 1964, 0313; Purtymun 1984, 0196). Sedimentary rocks usually dominate the Santa Fe Group, although basalts constitute up to 45% of the section penetrated by water supply wells at the Laboratory (Purtymun et al. 1984, 0713). In the Española

basin and underlying the northern part of Los Alamos County, the Santa Fe Group is subdivided into two formations (Tesuque and Chamita formations) and several members, which reflects the diversity of the coalesced alluvial fans deposited in the Española basin (Galusha and Blick 1971, 0108; Ingersoll et al. 1990, 0533). Early investigators inferred that all Santa Fe Group rocks exposed around the flanks of the Pajarito Plateau and intersected by water wells beneath the plateau belonged to the Tesuque Formation (Griggs and Hem 1964, 0313; Cooper et al. 1965, 0495), although more recent investigations suggest that some of the upper Santa Fe Group in the vicinity of Los Alamos is instead Chamita Formation (Turbeville et al. 1989, 0221).

2.6.1.2.2 Keres Group

Two formations of the Keres Group (Bailey et al. 1969, 0019, and Gardner et al. 1986, 0310 discuss formational relations in the Keres Group) may be important in the pre-Bandelier Tuff subsurface in the southern parts of the Laboratory. These are the Paliza Canyon and Cochiti formations, each about 13 million to about 6 or 7 million years old. The St. Peter's Dome area lies about 3 mi from the southern boundary of the Laboratory and was a major center of Keres Group volcanism (Goff et al. 1990, 0557). Large volumes of Paliza Canyon andesite were erupted from the St. Peter's dome center and spread to the east and north. It appears that some of the volcanic units encountered in wells at TA-49 (Weir and Purtymun 1962, 0228) may be Paliza Canyon lavas that have been misidentified as Tschicoma and Cerros del Rio units, as discussed below.

Beneath the southern Pajarito Plateau, sedimentary deposits of the Cochiti Formation compose the Miocene basin fill and are therefore laterally equivalent to the sedimentary rocks of part of the Santa Fe Group and possibly also to those of the Puye Formation (Section 2.6.1.2.3) to the north (Gardner et al. 1986, 0310). The Cochiti Formation consists dominantly of basin fill gravels derived from the volcanic centers of the southern and central Jemez Mountains volcanic field. The transition between the Cochiti, Santa Fe, and Puye formations probably occurs somewhere beneath Los Alamos County, but it is very poorly defined.

2.6.1.2.3 Tschicoma Formation

The Tschicoma Formation consists of a sequence of dacitic domes and lavas that were erupted from vents in the central to northeastern Jemez Mountains between about 7 and 3 million years ago, (Gardner et al. 1986, 0310). These volcanic rocks outcrop extensively in the mountains immediately west of the Laboratory and are reported in the subsurface beneath the western and southern part of the Laboratory (Weir and Purtymun 1962, 0228; Griggs 1964 and Hem, 0313; Dransfield and Gardner 1985; 0082).

2.6.1.2.4 Puye Formation

The Puye Formation consists of a Pliocene-to-Pleistocene fanglomerate that was shed eastward from Tschicoma volcanic centers in the northeastern Jemez volcanic field between about 4 and 1.7 million years ago. Earlier workers (e.g., Griggs 1964 and Hem, 0313) included the Totavi Lentil, now considered a separate formation (Section 2.6.1.2.5), as part of the Puye Formation. Most of the Puye conglomerates contain cobbles of dacitic to andesitic composition in a volcanic sand matrix. The

beds include stream flow deposits, debris flow deposits, volcanic ash and block flow deposits, and ash fall and pumice fall deposits (Waresback and Turbeville 1990, 0543). The Puye Formation is best exposed north of the Laboratory, but lithologically similar rocks have been penetrated in drill holes as far south as Frijoles Mesa (Weir and Purtymun 1962, 0228; Dransfield and Gardner 1985; 0082). Under parts of the Laboratory, the Puye Formation is interstratified with basalts of the Cerros del Rio volcanic field. In Los Alamos water supply wells, the top of the main aquifer is usually within the Puye Formation.

2.6.1.2.5 Totavi Formation

Immediately beneath the fanglomerates of the Puye Formation, unconformably overlying the Santa Fe Group, is a section of poorly consolidated fluvial gravels, which Griggs originally named the Totavi Lentil of the Puye Formation (Griggs and Hem 1964, 0313). The gravels contain clasts that differ lithologically from those in the Puye, including abundant well-rounded cobbles and boulders of quartzite, granite, and pegmatite that record a source area distant from the Jemez Mountains; this unit probably represents axial channel gravels of an ancestral Rio Grande. Recently, Waresback and Turbeville (1990, 0543) redefined these fluvial gravels as a separate formation, the Totavi Formation, which also includes lacustrine sediments that are complexly interstratified with the upper Puye Formation ("old alluvium" of Griggs and Hem 1964, 0313). In some water supply wells beneath the Laboratory, the Totavi was reported between the Santa Fe and the Puye, occurring at lower elevations in the eastern wells (Cooper et al. 1965, 0495; Purtymun et al. 1983, 0712; Purtymun et al. 1984, 0713). The presence of the Totavi at these levels suggests that Rio Grande river gravels were deposited on erosional surfaces, a setting analogous to Quaternary terraces of the Rio Grande in the Española basin described by Dethier et al. (1988, 0773) before deposition of the Puye fans, which unconformably overlie older formations.

2.6.1.2.6 Cerros del Rio Basalts

Basaltic flows, breccias, and scoria of the Cerros del Rio occur in the subsurface beneath much of the Pajarito Plateau (Dransfield and Gardner 1985, 0082) and outcrop in the east and southeast parts of Los Alamos County (Griggs 1964 and Hem, 0313). These volcanic rocks are associated with the Pliocene-to-Pleistocene Cerros del Rio basalt field, east of the Rio Grande, and rocks from this field have been dated at 4.6 to 2.0 million years old (Gardner et al. 1986, 0310). The youngest lava flows in this area occurred between the two Bandelier Tuff eruptions, 1.5 and 1.13 million years ago ("basaltic andesite of Tank Nineteen" described by Smith et al. 1970, 0776). Part of this volcanic field is also known as basaltic rocks of Chino Mesa (Griggs and Hem 1964, 0313). The top of the main aquifer beneath the Laboratory is locally within this section of basaltic rocks.

2.6.1.2.7 Otowi Member, Bandelier Tuff

The Otowi Member of the Bandelier Tuff underlies the Tshirege Member in the subsurface beneath much of the Pajarito Plateau and outcrops in many of the canyons (Griggs and Hem 1964, 0313). The Otowi Member is mostly a nonwelded ash flow tuff (ignimbrite) that was erupted from the Jemez Mountains 1.5 million years ago (Spell et al. 1990, 0607). It is highly porous and poorly indurated and is composed of multiple flow units. Where it outcrops, cooling joints are typically absent

because of relatively low emplacement temperatures and the lack of induration. The Guaje Pumice Bed generally occurs at the base of the Otowi Member and consists of sorted pumice fragments that average 0.8 to 1.6 in. in size (Crowe et al. 1978, 0041).

2.6.1.2.8 Cerro Toledo Rhyolite and Interbedded Sediments

An interbedded sequence of rhyolitic tuffs and sediments commonly occurs between the Otowi and Tschirege members of the Bandelier Tuff. The rhyolitic tuffs were erupted between 1.5 and 1.2 million years ago, predominantly from the Cerro Toledo domes in the northeastern Jemez Mountains (Heiken et al. 1986, 0316). Beneath the Pajarito Plateau, the sediments are epiclastic sands and sandy gravels that lithologically resemble Puye Formation fanglomerates. At the Laboratory, deposits in this interval have sometimes been referred to as "Tsankawi pumice" or "Tsankawi member." These units may play an important role in the migration of water in the subsurface beneath the Laboratory (Stoker et al. 1991, 0715).

2.6.1.2.9 Tschirege Member, Bandelier Tuff

The most widespread rock unit on the Pajarito Plateau is the Tschirege Member of the Bandelier Tuff (Griggs and Hem 1964, 0313), which was erupted from the Valles caldera in the Jemez Mountains about 1.13 million years ago (Spell et al. 1990, 0607). The Tschirege Member is composed of multiple flow units of crystal-rich ash-flow tuff (ignimbrite) and displays significant variations in welding and alteration, both in a single stratigraphic section and with varying distance from the caldera. Individual units tend to be more welded and thicker to the west. Flow units are locally separated by volcanic surge deposits of well-sorted, fine-grained, cross-bedded crystal and pumice fragments. Vapor phase alteration, caused by postemplacement cooling and migration of entrained magmatic gases, occurs in much of this unit. The base of the Tschirege Member is often marked by 1.5 to 10 ft of bedded, unconsolidated, pumice-rich ash fall tuff of the Tsankawi Pumice Bed (Bailey et al. 1969, 0019; Crowe et al. 1978, 0041). The Tsankawi Pumice Bed is generally poorly recognized in drill bit cuttings because rotary drills commonly grind the soft materials into dust.

The Tschirege Member has been subdivided into a sequence of mappable units based on either erosional characteristics (Weir and Purtymun 1962, 0228; Baltz et al. 1963, 0024; Purtymun and Kennedy 1971, 0200) or on primary cooling units (Crowe et al. 1978, 0041). These units have been correlated over large distances on the Pajarito Plateau. However, the boundaries between the units are not always distinct in the field and can be difficult to recognize in drill holes, causing investigators to place the contacts between units at different locations. Furthermore, in the absence of geologic mapping in the intervening areas, the validity of the correlations is uncertain.

Stratigraphic features in the tuff, such as volcanic surge deposits, may locally provide a preferential migration pathway for moisture and contaminants in the subsurface (Purtymun 1973, 0710; Crowe et al. 1978, 0041). Purtymun (1973, 0710) noted increased rates of vapor phase migration of tritium away from storage shafts at TA-54 along a stratigraphic boundary that includes surge layers. Individual flow units in the Tschirege Member contain vertical cooling joints that may or may not cross flow unit boundaries. In ash flow tuffs, cooling joint spacing varies primarily with the thickness of the unit, emplacement temperature, substrate temperature, and topography. Joint density tends to be greatest in welded tuff and least in nonwelded tuff.

Hydraulic conductivities are generally greatest in the fractured, welded parts of ash flow tuffs and least in the nonwelded parts (Crowe et al. 1978, 0041).

2.6.1.2.10 Post-Bandelier Units

Stratigraphically overlying the Bandelier Tuff are discontinuous Quaternary alluvial units that occur as thin deposits (typically less than 15 ft thick) on mesa tops and as deposits in canyons. Alluvial fans consisting mostly of dacite debris are being shed over the Bandelier Tuff at the western boundary of the Laboratory. Well-sorted to poorly sorted sandy and gravelly alluvium occurs in the major drainages of the Pajarito Plateau, ranging up to at least 70 ft thick in some drill holes (Baltz et al. 1963, 0024). Additional, older alluvium occurs on stream terraces on the sides of the canyons, which can be buried by colluvial deposits from the canyon walls. The distribution of alluvial deposits on the mesas has not been mapped, but these deposits are most widespread on the western part of the Pajarito Plateau. Post-Bandelier alluvial units represent a range of ages from 1.1 million years ago to the present. Generally, alluvial units on the surface of the mesas are probably oldest, becoming inactive as drainages were incised into the plateau. Those units lowest in the drainages grade into the active alluvium along canyon bottoms.

The alluvial sediments in the canyon bottoms probably record a complex history of erosion and deposition, in part related to regional climatic changes. In Cabra Canyon, immediately north of Los Alamos, several cycles of erosion and deposition of sediment occurred over the last 6,000 years, during which most of the previously stored sediment was eroded (Gardner et al. 1990, 0639). Similar cycles of erosion and deposition have been documented in many parts of the southwestern United States, and the older alluvial units in the vicinity of Los Alamos may also record the effects of regional climatic changes (Dethier et al. 1988, 0773).

The mesas of the Pajarito Plateau are also covered in part by deposits of the El Cajete pumice, erupted from El Cajete crater in the Jemez Mountains. Deposits of pumice on the mesas have not been mapped, but at the Laboratory they are generally most common to the south, and the axis of the volcanic dispersal plume is south of Los Alamos County. Available data suggest that the El Cajete pumice is 130,000 to 170,000 years old (Self et al. 1988, 0500).

2.6.1.3 Soils

A large variety of soils have developed on the Pajarito Plateau as the result of interactions of the underlying bedrock, slope, and climate (Nyhan et al. 1978, 0161). The mineral components of the soils are in large part derived from the Bandelier Tuff, but dacitic lavas of the Tschicoma Formation, basalts of the Cerros del Rio volcanic field, and sedimentary rocks of the Puye Formation are locally important. Alluvium derived from the Pajarito Plateau and from the east side of the Jemez Mountains contributes to soils in the canyons and also to those on some of the mesa tops. Layers of pumice derived from El Cajete in the Jemez Mountains and windblown sediment derived from other parts of New Mexico are also significant components of many soils on the Pajarito Plateau.

Soils formed on the tops of mesas on the Pajarito Plateau include the Carjo, Frijoles, Hackroy, Nyjack, Pogna, Prieta, Seaby, and Tocal series. These soils typically have loam or sandy loam surface horizons and clay or clay loam subsurface horizons. Some, including the Frijoles, Hackroy, and Seaby soils, contain abundant pumice.

Others, including the Prieta soils, contain abundant wind-deposited sediment. Soils on the mesas can vary widely in thickness and are typically thinnest near the edges of the mesas, where bedrock is often exposed. Soils formed from alluvial and colluvial deposits include the Potrillo, Puye, and Totavi series and are generally loose and sandy. The slopes between the mesa tops and canyon bottoms often consist of steep rock outcrops and patches of shallow, undeveloped colluvial soils. South-facing canyon walls are steep and usually have little or no soil material or vegetation; in contrast, the north-facing walls generally have areas of very shallow, dark-colored soils and are more heavily vegetated (Nyhan et al. 1978, 0161).

Soil-forming processes extend along fractures in bedrock, and coatings of clay and calcium carbonate on fractures record the transport of water to significant depths in the tuff. For example, at TA-54, Area G, calcium carbonate has been observed as deep as 39 ft and clay coatings as deep as 46 ft below the ground surface (Purtymun et al. 1978, 0207). Roots have also been observed at similar depths along fractures in core holes and pits, suggesting that these soil-forming processes continue at depth today.

2.6.1.4 Geologic Structure

As mentioned earlier, the Laboratory is on the Pajarito Plateau, which lies at the western margin of the Española Basin of the Rio Grande rift, a major tectonic feature of the North American continent. The Pajarito fault system forms the western margin of the Española basin and exhibits Holocene movement and historic seismicity (Gardner and House 1987, 0110; Gardner et al. 1990, 0639; Gardner and House, in preparation, 0720). The fault system is made up of over 65 mi of mapped fault traces and connects with regional structures that extend at least as far as Cochiti to the south and Taos to the northeast (Gardner and House 1987, 0110).

Within Los Alamos County, the Pajarito fault system consists of three active, or potentially active, fault segments: the Frijoles Canyon, Rendija Canyon, and Guaje Mountain segments. The Frijoles Canyon fault segment is a zone of faulting over 0.25 mi in width, whose major scarp forms the western boundary of the Laboratory. Near the southwestern corner of the Laboratory, the major scarp of the Frijoles Canyon segment is over 410 ft high in rocks about 1 million years old. Movement on this fault segment is normal-oblique, and the fault's eastern side is relatively downdropped. Where exposed north of Los Alamos Canyon, the Rendija Canyon and Guaje Mountain faults are characterized by zones of gouge and breccia generally 100 to 150 ft wide. Both fault segments produce visible offsets of stratigraphic horizons and are dominantly normal-oblique faults whose west sides are downdropped. There are some indications of strike-slip movements on the Guaje Mountain fault segment (Wachs et al. 1988, 0502; Aldrich and Dethier 1990, 0017; Gardner et al. 1990, 0639). The youngest movements on the Guaje Mountain segment have been constrained to between roughly 4,000 and 6,000 years ago (Gardner et al. 1990, 0639). Displacement on the Guaje Mountain and Rendija Canyon faults apparently decreases south of Los Alamos Canyon, and narrow zones of faulting are replaced by wide (over 300 ft) zones of intense brecciation and fracturing superimposed on the network of cooling joints in the Bandelier Tuff (Vaniman and Wohletz 1990, 0541). In contrast to cooling joints, these tectonic fractures cross flow unit and lithologic unit boundaries; thus, tectonic fractures may provide more continuous and more deeply penetrating flow paths for groundwater migration than do cooling joints.

Dransfield and Gardner (1985, 0082) integrated a variety of data to produce structure contour and paleogeologic maps of the pre-Bandelier Tuff surface beneath the Pajarito Plateau. Their maps reveal that subsurface rock units are cut by a series of down-to-the-west normal faults; the overlying Bandelier Tuff is not obviously displaced by these buried faults. However, where detailed fracture studies have been done on the plateau, they have shown that fracture abundances and apertures increase in the Bandelier Tuff over fault projections, which indicates the tectonic fracturing mentioned above (Vaniman and Wohletz 1990, 0541). In addition, small-scale offsets along fractures have been observed in various parts of the Laboratory, including Area G at TA-54 (Rogers 1977, 0216), that suggest additional unmapped fault zones. Unfortunately, detailed fracture studies on the Pajarito Plateau are few.

2.6.1.5 Seismicity and Volcanism

The Laboratory lies within a region that possesses a long and rich history of volcanic and tectonic activity that dates from the distant past into the Late Pleistocene and present, respectively. Volcanism began in the Jemez Mountains volcanic field more than 13 million years ago and continued without significant hiatus up through about 130,000 years ago (Gardner et al. 1986, 0310). Reports of questionable reliability describe what were apparently phreatic explosions and possible associated earthquakes within the volcanic field around 100 years ago (Santa Fe *Daily New Mexican* 1882, 0780). Regardless, given the long history of spatially focused, geologically continuous volcanic activity, future volcanism is expectable. Although volcanic activity directly affecting the Laboratory may prove unlikely, sufficient data to quantify the probabilities and nature of future volcanism are lacking.

Direct effects of future seismicity at the Laboratory are likely, although quantification of probabilities is not possible at present. Numerous small earthquakes are recorded in the Los Alamos area and northern New Mexico each year (Sanford 1979, 0540; Cash and Wolff 1984, 0530; Gardner and House 1987, 0110). Since establishment of the Laboratory, several earthquakes of Richter magnitude 3 to 4 have shaken Los Alamos (Gardner and House 1987, 0110). Recent work has shown that three fault segments in Los Alamos County are seismically active and that they are capable of generating large earthquakes of about 7 or more on the Richter scale (Gardner and House 1987, 0110; House and Cash 1988, 0132; Gardner et al. 1990, 0639; Gardner and House in preparation, 0720). Unknown at this time are how frequently these large earthquakes occur and what their potential is for generating surface rupture and mass wasting (occurrences such as rockfalls and landslides, which are not caused primarily by the movement of water) within the confines of the Laboratory.

2.6.1.6 Geomorphic Processes

Significant geomorphic processes active on the Pajarito Plateau include (1) erosion of mesa top soils by run-off, (2) retreat of canyon walls by rockfall and landsliding, (3) colluvial transport on sloping portions of canyon walls, and (4) erosion and deposition of sediments by streams in the canyon bottoms. Few data exist on the rates of erosion and landscape change caused by these different processes on the Pajarito Plateau. Estimates of long-term vertical erosion rates on mesa tops have been made based on stripping of overlying units (Purtymun and Kennedy 1971, 0200), but these estimates may be of limited value because the resistant, cliff-forming units may be eroded primarily by lateral cliff retreat rather than by vertical erosion. Erosion rates vary considerably on the mesa tops; the highest rates occur in and near drainage channels and in areas of locally steeper slope gradient, and the

lowest rates occur on relatively gently sloping portions of the mesa tops removed from channels. Areas where run-off is concentrated by roads and other development are especially prone to accelerated erosion.

The rates and processes of erosion may differ significantly between the north and south slopes of canyons. Given current vegetation and climate, the more extensive exposures of bedrock on south-facing sides and greater soil cover on north-facing sides suggest that erosion rates of fine-grained material that can be transported by run-off are higher on the drier, less-vegetated, south-facing sides of canyons, although this material is largely retained on the north-facing slopes. However, no studies have been conducted to quantify the rates and processes of erosion on canyon sides.

Cliff faces retreat primarily by dislodgement of blocks bounded by joints and, to a lesser extent, by large-scale landsliding, including the formation of huge toreva blocks in White Rock Canyon. At present, the rates of cliff retreat have not been documented. Neither is it known to what extent cliff retreat rates may vary with climatic changes, with evolution of the canyons, or with proximity to side drainages.

Thicknesses, detailed stratigraphy, and ages of alluvium in canyon bottoms are, in general, poorly known, and therefore the rates of deposition, erosion, and transport of sediments through canyons are largely unknown. Available studies that have examined alluvial stratigraphy on the Pajarito Plateau reveal multiple cycles of extensive erosion of sediment, followed by renewed deposition, in the past 6,000 years (Gardner et al. 1990, 0639). At Cabra Canyon, north of Los Alamos, the last few hundred years has been marked by the net accumulation of sediment in the canyon bottom (Gardner et al. 1990, 0639), but it is not known how long this sediment will stay in storage before being mobilized by floods and transported downcanyon. It is possible that these erosional cycles are climatically driven and regional in extent, but more extensive data from additional canyons are needed before this determination can be made. On a longer time scale, evidence from the adjacent Española basin does suggest a strong climatic control on periods of alluviation and canyon incision over the last million years (Dethier et al. 1988, 0773).

2.6.2 Hydrology

2.6.2.1 General Surface Water Conditions

The Rio Grande is the master stream in north-central New Mexico. All surface water drainage and groundwater discharge from the Plateau ultimately arrives at the Rio Grande. The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 14,300 mi^2 in southern Colorado and northern New Mexico. The discharge for the period of record has ranged from a minimum of 60 cubic feet per second (cfs) in 1902 to 24,400 cfs in 1920. The river transports about one million tons of suspended sediments past Otowi annually.

Essentially all Rio Grande flow downstream of the Laboratory passes through Cochiti Reservoir, which began filling in 1976. It is designed to provide flood control, sediment retention, recreation, and fishery development. Flood flows are temporarily stored and released at safe rates. The dam is expected to trap at least 90% of the sediments carried by the Rio Grande.

Los Alamos surface water occurs primarily as intermittent streams in canyons cut into the Pajarito Plateau. Perennial flow to the Rio Grande occurs in the Rito de los Frijoles to the south of the Laboratory and in Santa Clara Canyon to the north. Spring discharges in lower Pajarito and Ancho Canyons in White Rock Canyon also are of sufficient volume to supply perennial flow into the Rio Grande.

Springs between elevations 7,900 and 8,900 ft mean sea level on the flanks of the Jemez Mountains supply base flow throughout the year to the upper reaches of Cañon de Valle and in Guaje, Los Alamos, Pajarito, and Water Canyons (Purtymun 1975, 0194). These springs discharge water perched in the Bandelier Tuff and Tschicoma Formation at rates from 2 to 135 gal./min (Abeele et al. 1981). The volume of flow from the springs is insufficient to maintain surface flow within more than the western third of the canyons before it is depleted by evaporation, transpiration, and infiltration into the underlying alluvium.

Eleven drainage areas, with a total area of 82 mi^2, pass through the Laboratory's eastern boundary. Run-off from heavy thunderstorms and heavy snowmelt reaches the Rio Grande several times a year in some drainages. Los Alamos, Pajarito, and Water Canyons have drainage areas at the east boundary of greater than 10 mi^2. Pueblo Canyon has 8 mi^2, and all the rest have less than 5 mi^2. Theoretical maximum flood peaks range from 24 cfs for a 2-year frequency to 686 cfs for a 50-year frequency (McLin 1992, 0825). The overall flooding potential is low because nearly all community and Laboratory structures are located on the mesa tops, which drain rapidly into the deep canyons.

Contaminants enter the surface water drainages by surface run-off, by liquid discharges, and occasionally by air deposition (Becker 1985, 0029; 1986, 0027). Run-off-derived contaminants are largely bound to sediments; their rate of downstream travel is governed by the scouring and carrying power of subsequent run-off events (Lane et al. 1985, 0140). Given sufficient time, these sediments eventually will be moved across the Laboratory boundary.

Nearly every drainage has received liquid industrial or sanitary effluents discharged from the Laboratory. The effluent discharges determine the flow and water quality characteristics in drainages that contain little natural water. With travel downstream, most of the effluent-derived metals and radionuclides become sediment bound and remain near the surface of the stream channel; other contaminants, such as nitrate, are lost by evaporation or move downward into the alluvium. Detailed field investigations in Mortandad Canyon, for example, demonstrate that generally more than 99% of the residuals from the treatment plant effluents are associated with sediments in or immediately adjacent to the stream channel (Stoker et al. 1991, 0751). *

In canyons that have received treated, low-level radioactive effluents (Acid-Pueblo, DP-Los Alamos, and Mortandad canyons) concentrations of radioactivity in the alluvium are generally highest near the treated effluent outfall and decrease downhill in the canyon as the sediments and radionuclides are transported and dispersed by other treated industrial effluents, sanitary effluents, and surface run-off.

A study of transport of plutonium by snowmelt run-off was published in 1990 (Purtymun et al. 1990, 0215). The conclusions include the finding that most plutonium moved by run-off in Los Alamos and Pueblo canyons that reached the Rio Grande is transported with sediments—about 57% with suspended sediments and 40% with bed sediments. A total of about 600 uCi of plutonium was carried to the Rio Grande by five snowmelt run-off events studied during the years 1975 to 1986. *

Environmental monitoring for chemical and radiochemical quality in surface water began with US Geological Survey (USGS) investigations (Purtymun 1964, 0183; 1975, 0194; Purtymun and Kunkler 1967, 0202; Purtymun 1967, 0188) and have been continued by the Laboratory (ESG 1970-1991).

2.6.2.2 General Groundwater Conditions

Groundwater occurs in three modes in the Los Alamos Area: (1) water in shallow alluvium in some of the larger canyons, (2) as perched water (groundwater body above a less permeable layer that separates it from the underlying main aquifer by an unsaturated zone), and (3) the main aquifer of the Los Alamos area.

2.6.2.2.1 Alluvial Canyon Aquifers

Intermittent and ephemeral streamflows in the canyons of the Pajarito Plateau have deposited alluvium that ranges in thickness to as much as 100 ft. The alluvium in canyons that head on the Jemez Mountains is generally composed of sands, gravels, pebbles, cobbles, and boulders derived from the Tschicoma Formation and Bandelier Tuff on the flank of the mountains. The alluvium in canyons that head on the plateau is comparatively more finely grained, consisting of clays, silts, sands, and gravels derived from the Bandelier Tuff. Saturated hydraulic conductivity of the alluvium ranges from 1.65×10^{-3} m/s for a sand aquifer to 5.8×10^{-4} m/s for a silty sand aquifer (Abeele et al. 1981, 0009).

In contrast to the underlying volcanic tuff and sediments, the alluvium is quite permeable. Ephemeral run-off in some canyons infiltrates the alluvium until downward movement is impeded by the less permeable tuff and sediments, which results in a buildup of a shallow alluvial groundwater body. Depletion by evapotranspiration and movement into the underlying rocks limits the horizontal and vertical extent of the alluvial water (Purtymun et al. 1977, 0206). The limited saturated thickness and extent of the alluvial groundwater preclude its use as a viable source of municipal and industrial supply to the community and the Laboratory. Lateral flow in the alluvial aquifers is in a easterly, down-canyon direction. Tracer studies in Mortandad Canyon have shown that the velocity of water ranges from about 60 ft/day in the upper reach to about 7 ft/day in the lower reach of the canyon (Purtymun 1974, 0192).

The water quality in the alluvial aquifers is variable, depending on the location and history of effluent discharges. In Mortandad Canyon, for example, plutonium concentrations fluctuate up and down in response to variations in the treatment plant effluent and storm run-off water, which cause some dilution in the shallow alluvial aquifer. The tritium concentrations have fluctuated almost in direct response to the average annual concentration of tritium in the TA-50 effluent, with a lag time of about one year (Environmental Protection Group 1992, 0740).

Good reviews of alluvial aquifers by drainage area are have been written by Purtymun (1975, 0194; 1973, 0191). The results of an extensive monitoring study of the alluvial aquifer in Mortandad Canyon are presented by Abrahams et al. (1962, 0231), Baltz et al. (1963, 0024), Purtymun (1973, 0191), Purtymun (1974, 0192), Purtymun et al. (1977, 0206), Purtymun et al. (1983, 0209), and Stoker et al. (1991, 0751).

2.6.2.2 Perched Water in Volcanic Sediments and Basalts

Perched water bodies occur in the conglomerates and basalts beneath the alluvium in the mid- and lower reaches of Pueblo and Los Alamos Canyons and in the lower reach of Sandia Canyon. Depth to perched water ranges from about 90 ft in the midreach of Pueblo Canyon to about 450 ft in lower Sandia. The vertical and lateral extent of the perched aquifers, the nature and extent of perching units, and the potential for migration of perched water to the main aquifer have not been addressed by investigators to date. Only the body in lower Pueblo and Los Alamos Canyons has been studied in some detail.

Patterns of chemical quality and water level measurements indicate that the lower Pueblo Canyon perched aquifer is hydrologically connected to the stream in Pueblo Canyon (Abrahams 1966, 0014). Water from this perched aquifer discharges at the base of the basalt at Basalt Spring, which is off the Laboratory site in lower Los Alamos Canyon on the San Ildefonso Pueblo. The rate of movement in the aquifer in this vicinity has been estimated at about 60 ft/day or about 6 months from recharge to discharge (Abrahams 1966, 0014).

It is unknown if the perched water systems are hydraulically interconnected. Available data however suggest that most of the systems are of limited extent: testing of the perched system in mid-Pueblo Canyon resulted in depletion of the aquifer after about an hour's pumping at 2 to 3 gal./min (Weir et al. 1963, 0395). Additionally, perched water was encountered in mid-Los Alamos Canyon during the drilling of the Otowi-4 supply well (Stoker et al. 1992, 0826). This perched aquifer may be of limited extent because it was not encountered in an adjacent well (Test Well 3) located 300 ft to the east.

Perched in the or beneath?

Some perched water occurs in volcanics on the flanks of the Jemez Mountains offsite to the west of the Laboratory. This water discharges in several springs (American and Armistead Springs) and provides flow for the gallery in Water Canyon. The gallery contributed to the Los Alamos water supply for 41 years, producing 23 to 96 million gallons annually.

2.6.2.2.3 Main Aquifer

The main aquifer of the Los Alamos area is the only aquifer capable of large-scale municipal water supply (Purtymun 1984, 0196). In 1989, water for the Laboratory, the communities of Los Alamos and White Rock, and Bandelier National Monument was supplied from 16 deep wells in three well fields and from the Water Canyon gallery. The wells are located on the Pajarito Plateau and in Los Alamos and Guaje canyons east of the plateau. Municipal and industrial water supply during 1989 was 1.69 billion gallons, with individual well yields ranging from about 300 to 1,300 gpm (Stoker et al. 1992, 0826). Purtymun (1984, 0196) summarizes aquifer hydraulic characteristics as determined during aquifer tests or during periods of production of supply wells and test holes.

The surface of the main aquifer rises westward from the Rio Grande within the Santa Fe Group into the lower part of the Puye Conglomerate beneath the central and western part of the plateau. The depths to water below the mesa tops range from about 1,200 ft along the western margin of the plateau to about 600 ft at the eastern margin. The main aquifer is separated from the water in the alluvium and perched water in the volcanics by 350 to 620 ft of tuff and volcanic sediments (Environmental

Protection Group, in preparation, 0829). The main aquifer is unconfined in the western part of the plateau and exhibits semiartesian to artesian conditions in the eastern part along the Rio Grande (Purtymun 1984, 0196).

Available hydrologic data indicate that the major recharge area for the main aquifer is west of the Laboratory, presumably in the Jemez Mountains (Figure 2-4). The water in the aquifer moves from its major recharge area toward the Rio Grande, where a part is discharged into the river through seeps and springs (Purtymun et al. 1980, 0208). Springs fed by the main aquifer discharge an estimated 4,300 to 5,000 acre-ft of water annually into White Rock Canyon along an 11-mi reach between Otowi Bridge at State Road 502 and the mouth of Rito de Frijoles (Cushman 1965, 0042). Goff and Sayer (1980, 0824) indicate through stable-isotope data that groundwater in the lower part of the Los Alamos well field may be recharged from somewhere else, possibly the Sangre de Cristo Mountains to the east across the Rio Grande.

The hydraulic gradient of the aquifer averages about 60 to 80 ft /mi within the Puye Conglomerate but increases to 80 to 100 ft/mi along the eastern edge of the plateau as the water in the aquifer enters the less permeable sediments of the Santa Fe Group. The rate of movement of water in the upper section of the aquifer varies, depending on the aquifer materials. Aquifer tests indicate the movement ranges from 20 ft/yr in the Tesuque Formation to 345 ft/yr in the more permeable Puye Conglomerate (Purtymun 1984, 0196).

In an effort to better understand the nature of recharge to the main aquifer in the Los Alamos area, a series of isotope and age-dating measurements on selected water samples have been initiated by Laboratory and other DOE researchers. To date, low-detection-limit tritium analyses have been completed on 12 samples from springs in White Rock Canyon and on 5 samples from wells into the main aquifer (Environmental Protection Group, in preparation, 0829).

The values for tritium in the water range from less than detectable to about 18 pCi/L. The values are all less than values for tritium in contemporary precipitation (about 30 to 60 pCi/L) and much less than the roughly 700 pCi/L that would be present now in water precipitated in northern New Mexico during 1962 and 1963, when tritium from atmospheric nuclear weapons testing was at its maximum (Environmental Protection Group, in preparation, 0829). The conclusion is that there cannot be any significant component of recharge from water precipitated during the last several decades in the water from the main aquifer. The inference is that the water is considerably older.

2.6.2.3 Hydrologic Properties and Conditions of the Bandelier Tuff

At the central portion of the Laboratory, there is in excess of 1,000 ft of unsaturated volcanic tuff, sediments, and basalts of the Bandelier Tuff, the Puye Conglomerate, and the basaltic rocks of Chino Mesa. Because of its extent and great thickness, the Bandelier Tuff is the most important geologic unit at Los Alamos from a waste management perspective.

Numerous investigations focusing on hydrologic characterization of the upper 100 ft of the Bandelier Tuff have been conducted in the Los Alamos area since the 1950s (e.g., Abrahams et al. 1961, 0015; Weir and Purtymun 1962, 0228, Abrahams 1963, 0011; Purtymun and Koopman 1965, 0201; Purtymun and Kennedy 1971, 0200; Purtymun et al. 1978, 0207; Abeele et al. 1981, 0009; Kearl et al. 1986, 0135;

Purtymun et al. 1989, 0214; Stoker et al. 1991, 0751). The vadose zone below about 100 ft has not been adequately characterized. (The vadose zone is the zone between the ground surface and the main aquifer, excluding the alluvial and perched aquifers).

Most of the investigations of hydrogeologic properties of the Bandelier Tuff have been conducted on samples of crushed or disturbed tuff. Hydrologic property tests conducted since the mid-1980s largely have been on undisturbed cores (e.g., Kearl et al. 1986, 0135; Stoker et al. 1991, 0751).

2.6.2.3.1 Effects of Physical Characteristics

Physical characteristics of the tuff that affect fluid flow result primarily from the degree of welding and jointing. The degree of welding, which varies markedly within and between tuff units, influences the nature and variability of hydrologic characteristics. Welding results in increased density, decreased porosity, and decreased hydraulic conductivity of the rock matrix (Purtymun and Koopman 1965, 0201). However, welded tuffs tend to be more highly fractured (jointed) than nonwelded tuff, and the overall permeability of the welded tuff may be locally enhanced (Crowe et al. 1978, 0041).

2.6.2.3.2 Porosity

Porosity measurements by Abrahams (1963, 0011) range from 20% to 60% by volume, generally decreasing with increasing degree of welding. Measurements reported by IT Corporation (1987, 0327) are higher, from approximately 39% to 74%. A great deal of the high porosity occurs when pumice fragments are incorporated in the tuff. The higher porosities are comparable to those of the upper ranges found in fine clays. Such high porosities, however, are unusual for consolidated materials. Extreme changes in porosity over a short vertical distance have been observed (Abrahams 1963, 0011).

2.6.2.3.3 Moisture Content

A number of hydraulic properties of the Bandelier Tuff vary with changing moisture content. The tuff is only partially saturated throughout the Laboratory, even beneath stream channels containing alluvial aquifer systems. The moisture contents of the tuff beneath mesa tops are very low, typically less than 5% by volume (Abrahams 1963, 0011). Studies by Abrahams (1963, 0011) show that tuff moisture contents are higher beneath disturbed soils than undisturbed soils and, generally, moisture content decreases with depth. At sites with relatively high near-surface moisture contents, the volumetric moisture content decreases rapidly with depth to less than 5% (Abrahams 1963, 0011). Moisture contents of the tuff beneath the canyon bottoms are considerably higher than those beneath the mesas, typically ranging 20% to 50% by volume (Weir and Purtymun 1962, 0228; Stoker et al. 1991, 0751). Field studies in Mortandad, Sandia, and Potrillo canyons show that moisture content varies greatly with depth, depending on texture (Stoker et al. 1991, 0751; Environmental Protection Group, in preparation, 0829). Generally, moisture content decreases with depth below stream channels.

2.6.2.3.4 Moisture Characteristic Curves

The relationship between moisture content and soil-water potential has been obtained from undisturbed mesa top cores at TA-54 (Kearl et al. 1986, 0135). Their data indicate (1) extremely high residual moisture contents ranging up to 80%, and (2) a low air-entry pressure head. Purtymun and Stoker (1987, 0204) indicate that at TA-49 specific retention (residual moisture content) ranged from 11% to 27%. These latter results are fairly consistent with recent tests on undisturbed tuff samples in Mortandad Canyon (Stoker et at. 1991, 0751). However, detailed analyses in Mortandad Canyon show that there are significant differences in moisture retention characteristics between and within formational units. The energy relationship with moisture content of a moderately welded tuff was determined by Abrahams (1963, 0011). The saturated moisture content of the tuff was about 41% by volume. When moisture contents are below about 4%, there is no movement of water; from about 4% to 8%, moisture is redistributed by diffusion; from about 8% to 23%, distribution is by gravity and capillarity, and above 23%, the movement is by drainage from gravity.

2.6.2.3.5 Hydraulic Conductivity

Hydraulic conductivity is the parameter that describes rate of flow of fluid through a porous medium in response to a hydraulic gradient; it is a function of both the fluid and the medium. Saturated hydraulic conductivities have been measured for tuff many times under laboratory and field conditions, with values ranging from 1.9×10^{-5} to 2.3×10^{-2} cm/s (0.054 to 6.5 ft/day), comparable to those of silty sand. In general, nonwelded tuff has greater saturated conductivity than welded tuff, and horizontal conductivities are greater than vertical conductivities (Abrahams 1963, 0011). Unsaturated hydraulic conductivities may be many orders of magnitude lower, typically ranging from 10^{-6} to 10^{-11} cm/s (Stoker et al. 1991, 0751; IT Corporation 1987, 0327), depending on in-situ moisture contents. The lower unsaturated hydraulic conductivities are comparable to those of marine clay.

2.6.2.3.6 Joints

Joints formed by cooling of the ash flows or by later faulting typically divide the tuff into irregular blocks. The major joint sets are vertical or near vertical, with dips greater than 70°, and joint frequency increases with the degree of welding. Joints and fractures in moderately welded tuffs generally terminate in nonwelded tuffs (Baltz et al. 1963, 0024). The joints are often vertically limited to a single ash flow or ash fall unit (Purtymun and Kennedy 1971, 0200). Joint apertures range from closed to open as much as several centimeters. The joints are commonly filled with caliche near the surface, grading downward to clay, and may be open to depths greater than 30 ft (Purtymun et al. 1978, 0207; Abeele et al. 1981, 0009). Examination of cores obtained from horizontal drilling beneath a waste disposal site at TA-54 showed that about 80% of the joints were filled or plated with clay or secondary mineralization (Purtymun et al. 1978, 0207).

2.6.2.4 Movement of Moisture in the Bandelier Tuff

The movement of moisture in the Bandelier Tuff is governed by a complex interaction of many factors. Climatic and site-specific land use factors control the supply of

moisture available for infiltration, and hydrogeological characteristics control the redistribution of moisture in the tuff.

Perhaps the most significant aspect of the tuff is its ability to act as a sponge. Most of the pore spaces in the tuff are of capillary size and have a strong tendency to hold water against gravity by surface tension forces. Thus, a slug of water entering dry tuff is slowed or retained by capillary tension forces.

Water moves through the tuff in two ways: (1) by liquid and vapor movement through the pores of the tuff and (2) by movement through open, interconnected joints (Abrahams, 1963, 0011). When moisture content is low, movement in the vapor (gaseous) phase becomes more preponderant and liquid movement through the rock matrix is extremely slow. Water entering open, interconnected joints might move rapidly downward through the joints; however, to maintain continual flow through the fractures, it is likely that large volumes and a continuous supply of water are necessary because of the sponge effect of the adjacent tuff that forms the wall of the fracture. The existence of a low-permeability coating on the wall of the fracture, on the other hand, could increase the travel depth of water flowing through fractures (Thoma et al. 1992, 0827). If the joints are not continuous through contacts between subunits of the tuff, the water might be perched above the contact and would tend to move laterally.

These factors are discussed as they pertain to subsurface contaminant transport beneath the mesa tops and canyon bottoms.

2.6.2.4.1 Migration of Moisture Beneath Mesa Tops

The natural moisture content of the tuff forming the mesas between the canyons is generally less than 5% by volume at depths greater than a few tens of feet, the zone affected by seasonal inputs of moisture and evapotranspiration. Weir and Purtymun (1962, 0228) attributed the low moisture content to the protective cap of clay soil derived by weathering of the tuff near the surface, low rainfall, and high evapotranspiration. The existence of low moisture content is further supported historically by the absence of weathering below 10 m (Wheeler et al. 1977, 0828) and the overall absence of perched water in the tuff at potential perching horizons.

Kearl et al. (1986, 0135) concluded that vapor phase transport is the predominant transport mechanism controlling the potential subsurface movement of contaminants beneath the mesa top at TA-54. Their evidence includes the low overall moisture content of the tuff and the relatively high moisture retention characteristics of the underlying rock. They also conclude that there is no interconnection or movement of liquid water in the interval of Bandelier Tuff examined (upper 100 ft of Tshirege Member). Laboratory analyses on cores of moderately welded tuff support the possibility of vapor phase dominance at most mesa top locations (Abrahams 1963, 0011).

From a waste containment perspective, the possibility of vapor phase dominance is significant: in extremely dry rock, only contaminants existing in a gaseous state, such as tritium or volatile organic solvents, migrate through the rock matrix. Other radionuclides and metals can be removed from their original location only under wetter conditions, when the movement of liquid water (i.e. capillarity) is more predominant.

Unfortunately, there are no definitive field measurements that quantify natural recharge through mesa tops. However, the flux of liquid water through the rock matrix that could eventually become recharge can be estimated as being approximately equal to the unsaturated hydraulic conductivity at the field moisture content (Kearl et al. 1991, 0652). A likely range for natural recharge through the rock matrix therefore is 10^{-6} to 10^{-11} cm/sec (1 ft//yr to 0.00001 ft/yr) based on the hydraulic conductivity values discussed above. At TA-54, Kearl et al. (1986, 0135) calculated maximum downward flux rates of 0.5 ft/year. These calculated flux rates are relatively low and carry the implication of very little water movement from the mesa tops to the main aquifer under natural conditions, which probably also applies to a one-time spill of contaminants at the land surface.

The greatest concern about subsurface migration is the potential for a large volume of enriched contaminant source to be chronically released in the vicinity of open and interconnected joints, which could occur beneath a surface impoundment or a leaky chemical storage tank. The movement of water through joints would negate the protection provided to the groundwater when water moves only through pores in the tuff (Abrahams 1963, 0011).

Filled fractures strongly inhibit moisture movement. Open fractures are effective barriers to liquid phase unsaturated flow but may provide preferential flow paths for vapor transport or rapid movement of liquid under saturated or near-saturated conditions (Abeele et al. 1981, 0009). Roots have been found in joints to depths of at least 58 ft (Weir and Purtymun 1962, 0228), which suggests that joints may be important local infiltration pathways. Several fracture zones at TA-54 show an increase in moisture content relative to adjacent porous media (Kearl et al. 1986, 0135).

Although fractures have a local effect on infiltration in the upper portions of the mesas, it is less clear to what depth they play a role for three key reasons. First, water passing through a fracture system has a tendency to be "wicked" into the adjacent rock matrix by capillary suction forces in the tuff, provided the fracture/rock interface is not sealed with material of low permeability (Thoma et al. 1992, 0827). Second, most of the open fractures occur in the moderately welded to welded Tschirege Member of the Bandelier Tuff, and the underlying nonwelded Otowi Member is significantly less fractured (Baltz et al. 1963, 0024). Flow in the lower portions of the Bandelier Tuff, therefore, is far more likely to be dominated by the relatively slow process of capillarity.

Finally, although fractures may initially provide a pathway for movement of water into the mesas, they may later play a role in removing water (as water vapor) from within the mesa. Under low barometric pressure conditions, transfer of air occurs from the tuff to the atmosphere through boreholes Purtymun et al. 1974, 0651. It is possible that barometric and air pressure variations along the canyon walls could cause the exchange of gas and water vapor between the atmosphere and the mesas, especially via interconnected fractures and joints, which are highly permeable to air. Air transfer has been documented in boreholes penetrating the tuff at TA-49 (Purtymun et al. 1974, 0651) and has been observed elsewhere on the plateau, but studies at TA-54 have been inconclusive (Abeele et al. 1981, 0009; Kearl et al. 1986, 0135).

In conclusion, the combination of the Bandelier Tuff's low moisture content beneath the mesa tops, its associated hydraulic characteristics, and its thickness provides the main aquifer a substantial degree of protection from the mesa tops. At suspected waste sites at which contaminated liquids have not been disposed, the risks to the

main aquifer are quite low. Detailed characterization of the subsurface probably is not warranted for most such sites. Nonetheless, at waste sites with large potential contaminant source terms, such as material disposal areas, phased subsurface investigations should be conducted to verify that the waste is sufficiently contained as judged by risk analyses.

Waste disposal activities that chronically released large volumes and highly contaminated liquids or that contain volatile contaminants have the potential for migration within the mesas and should also be investigated for subsurface transport. Open fractures may be a key factor in determining whether contaminants migrate to deeper sections of the tuff or travel laterally to release areas on the mesa walls. All of these subsurface investigations should initially focus on the upper 100 to 200 ft of the vadose zone.

2.6.2.4.2 Migration of Moisture Beneath Canyon Bottoms

The canyons with alluvial aquifers are presumed to represent a greater potential for downward movement than do the mesa tops because there is a constant driving force, and the moisture content of the tuff below the saturated alluvium is significantly higher than that beneath the mesas. The effect of this greater potential for fluid flow, though, is somewhat compensated by the general lack of highly concentrated contaminant sources in the canyon bottoms. The depth to the main aquifer in the canyons is several hundred feet less than from the adjacent mesa tops.

Recent investigations provide some important information on the movement of moisture and contaminants in the unsaturated tuff. The best field evidence that can be used to estimate potential downward rates of movement beneath canyon bottoms is obtained from corehole data collected by Stoker et al. (1991, 0751) in Mortandad Canyon. Because treated liquid radioactive effluents have been discharged to the canyon for almost 30 years, the radioactive constituents in effluent from the Laboratory serve as accurate tracers for fluid and contaminant migration studies.

The basic conclusions of the Mortandad study regarding the movement of radioactive contaminants below the alluvial aquifer are (1) soluble and particulate radioactive constituents have moved less than about 10 ft into the unsaturated zone beneath the alluvial aquifer and (2) tritium, as tritiated water (HTO), has moved at least 150 ft below the alluvial aquifer to a total depth of 195 ft. Tritium concentrations in Corehole MCM-5.9 (the deepest corehole drilled so far in the canyon) decrease by a factor of about 100 between 150 and 195 ft, suggesting the possibility that tritium has not moved much deeper in the almost 30 years since effluents were first released from the TA-50 treatment plant (Stoker et al. 1991, 0751). The tritium data suggest a downward rate of movement of at least 6 ft/yr . However, this conclusion must be considered tentative until additional, deeper coreholes can confirm the pattern.

Stoker et al. (1991, 0751) evaluated the moisture content in tuff beneath the alluvial aquifer in Mortandad Canyon. Most values for gravimetric moisture content in the Tschirege tuff beneath the alluvial aquifer ranged from 10% to 30%, corresponding to about 20% to 60% of saturation. Several peaks occurred at higher values, approaching 90% of saturation near the contact with or in the Tsankawi tuff and fluvial Cerro Toledo rhyolite deposits on the top of the Otowi member of the tuff at depths around 100 ft. In the Otowi tuff, the gravimetric moisture content decreased and leveled off at about 12% to 18%, which corresponds to 20% to 40% saturation. A similar pattern occurred in a corehole farther downstream in Mortandad Canyon past

the end of the alluvial aquifer (Stoker et al. 1991, 0751) and also in Sandia and Potrillo canyons (Environmental Protection Group, in preparation, 0829).

The data suggest that there are complex variations in hydrologic properties in the layers from the base of the Tschirege through to the top of the Otowi tuff that significantly affect the movement of moisture in the unsaturated zone. There is also a suggestion that moisture conditions in the Otowi tuff become very uniform with only moderate differences in magnitude, depending on whether there are saturated conditions in overlying layers (Environmental Protection Group, in preparation, 0829). Additional field data and theoretical interpretation are required to confirm the patterns and quantify movement.

2.6.2.5 Hydrologic Conditions at the Fenton Hill Site

The Fenton Hill site is located about 40 mi west of Los Alamos on the western flank of the Valles Caldera. Investigations in progress at this site are focused on the extraction of heat from dry geothermal reservoirs known as hot dry rock. Because site conditions here are significantly different from those on the Pajarito Plateau, Fenton Hill is briefly discussed separately.

Work at Fenton Hill is based on the concept of extracting heat from dry geothermal reservoirs by developing hydrothermal systems. The site contains a system of two deep holes completed in dry but hot Precambrian granite rock. The holes are connected by a series of large cracks created by hydraulic fracturing. Water circulated under pressure in the cracks recovers heat from the geothermal reservoir. Two separate systems, one at 9,000 ft depth and another at 15,000 ft, have been constructed and are being evaluated for potential energy development (Heiken 1985, 0131; Murphy et al. 1980, 0149).

Water for drinking and industrial supply needs at the Fenton Hill site is furnished by Well FH-1, which taps a perched aquifer at a depth of about 450 ft. An aquifer test conducted in 1980 determined that this aquifer is of limited extent (Becker et al. 1981, 0028). The water levels in FH-1 vary according to the amount of pumpage, which reflects the demand for drilling or testing at the site. The water level declined from 365 ft in 1976 to 382 ft in 1986. The decline in water level indicates that the withdrawal of water has exceeded the amount of recharge to the aquifer. Water quality in the well is good, where concentrations of total dissolved solids (TDS) generally range from 350 to 450 mg/L.

Environmental monitoring is performed in the vicinity of the site to assess any impacts from the geothermal operations. Water quality studies of surface and groundwaters, which include mineral and hot springs, wells, and streams, began before construction and testing of the hot dry rock reservoir. The results of water sampling are published in the Laboratory's annual surveillance reports (e.g., ESG 1989, 0308) and in reports on water quality in the vicinity of Fenton Hill (e.g. Purtymun et al. 1988, 0212). Purtymun et al. (1988, 0212) concluded that there were no significant changes from previous years in the chemical quality of surface and groundwater at the individual stations.

Surface and groundwater quality is generally good to excellent, with TDS concentrations ranging from less than 100 to about 450 mg/L. Two hot springs yield saline water typical of geothermal settings, with TDS concentrations ranging from about 2,000 to 4,500 mg/L.

2.6.3 Review of Studies on the Geohydrology of Mesa Tops and Vadose Zone

2.6.3.1 Middle Mesa

From 1945 through 1967, liquid radioactive wastes at TA-21, DP West, were discharged into a series of four seepage beds excavated in porous tuff underlying MDA T. Nyhan et al. (1984, 0165) provide details. MDA T is located on Middle Mesa between Los Alamos and DP canyons (Appendix C). About 98% of the estimated 10 Ci of plutonium discharged to adsorption beds was added between 1945 and 1952 (ESG 1974, 0094; Rogers 1977, 0216). Since 1945, several studies have been conducted to determine the vertical distribution of radionuclides beneath the adsorption beds at Area T. Nyhan et al. (1984, 0165) discuss and summarize the findings of earlier studies. The results of selected studies are briefly discussed here.

In 1953, the United States Geological Survey (USGS) drilled five 10- to 20-ft-deep holes in and around the adsorption beds. Analysis indicated that vertical migration of plutonium had occurred within 20 ft of the surface of the adsorption beds. Initial laboratory studies of the interaction of radionuclides in the liquid wastes with local soils and geologic materials were performed. Cores of Bandelier Tuff that had been exposed to waste solutions of plutonium retained essentially all of the radionuclides in the top few millimeters of the core (Christenson et al. 1958, 0244).

In 1959, the Laboratory initiated a field study to determine the distribution of plutonium previously discharged into an adsorption bed at MDA T (Christenson and Thomas 1962, 0039). This study indicated that plutonium had penetrated as far as 28 ft along fissures in the tuff.

In 1960 and 1961, researchers added 67 ft of water and wastewater to Adsorption Bed 1 in an attempt to change the distribution of plutonium beneath the bed from that shown in the 1953 and 1959 studies (Christenson and Thomas 1962, 0039; Abrahams 1963, 0012). This work concluded that water apparently moves through open joints. After the slug of water added to Adsorption Bed 1 had migrated for 17 years, plutonium and ^{241}Am were detected to sampling depths of 100 ft; however, these contaminants were only found at depths of 21 to 45 ft in an adjacent adsorption bed that had not received water in 1960 and 1961 (Nyhan et al. 1983, 0164). The results of a comprehensive field study by Nyhan et al. (1984, 0165) indicate that the vertical distributions of radionuclides and water are related to the occurrences of fractures and to variations in the geologic properties of the tuff units in each profile, as well as to the amount of water received.

2.6.3.2 Mortandad Mesa

2.6.3.2.1 Pit Infiltration Studies

In 1956, a test pit 2 ft in diameter by 1 ft deep was constructed on the mesa top between Mortandad and Pajarito canyons (Appendix C) to evaluate the infiltration properties of soil and tuff materials under ponded conditions (Abrahams et al. 1961, 0015). The pit penetrated only the upper portion of the 6-ft-thick soil cover. Water was introduced into the pit, and a constant water level was maintained at 0.75 ft for 99 days. Soil moisture measurements showed that, although the surficial soils

became saturated (38% by volume), the moisture content in the underlying tuff remained very low (4% by volume) 97 days after the test.

Although the quantity of water used during the study was equivalent to almost 50 years of precipitation on the Pajarito Plateau, the moisture content of the tuff below 8 ft was unchanged. The fact that water did not penetrate the dense transition zone between the soil and tuff during the study or during the following year indicates that the soil cover impedes vertical movement into the underlying tuff (Abrahams 1963, 0011).

2.6.3.2.2 Injection Well Studies

The USGS and UC began a study in 1964 to determine the hydrologic characteristics of the unsaturated Bandelier Tuff at TA-50 through the use of injection wells. Two injection wells and seven neutron moisture probe observation wells were completed to depths of between 60 and 295 ft in the Tschirege Member. (Water was injected at rates up to 16 gal./min for periods up to 89 days, and the movement of moisture from the injection zone into the adjacent tuff was monitored for periods approaching 1 year after the tests had ended (Purtymun et al. 1989, 0214).

In the longest of the tests, 335,000 gal. of water was injected over a period of 89 days. When injection ceased, a limited zone of saturation developed adjacent to the injection horizon. Gradually, however, the saturated zone dissipated as capillary forces redistributed the moisture in the unsaturated tuff until no further movement occurred. The downward movement of moisture was nearly arrested at a depth of about 210 ft.

The test results led the authors to conclude that the hydrologic characteristics of the unsaturated tuff can cause retention or arrest the movement of water-soluble contaminants originating from liquid or solid wastes stored in the tuff. A sufficient and nearly continuous water supply would have to be available before water-soluble contaminants could be rapidly mobilized to completely penetrate the unsaturated tuff.

2.6.3.2.3 Area C Studies

Five neutron moisture probe access holes were drilled in 1978, and moisture conditions were monitored for 16 months (Abeele et al. 1981, 0009). Moisture contents below 100 ft averaged 6% to 10% by volume and showed no significant net gradient.

2.6.3.3 Mesita del Buey

During the last 20 years, numerous subsurface investigations have been performed on Mesita del Buey between Pajarito Canyon and Cañada del Buey (Appendix C). These studies have been conducted to ensure that the mesita terrain can safely contain hazardous and radioactive wastes, specifically at MDAs G and L.

2.6.3.3.1 Hydrology and Geology Study

The stratigraphy of Mesita del Buey is typical of the remainder of the Pajarito Plateau. The mesa is covered by a clay-like soil and is underlain by a series of ash falls of rhyolite tuffs from 240 to 590 ft thick (Purtymun and Kennedy 1971, 0200). The tuffs are above the main aquifer of the Los Alamos area, which lies at depths of approximately 950 and 850 ft below Areas G and L, respectively, and has an average saturated thickness of 1,470 ft (Purtymun 1984, 0196). Purtymun and Kennedy (1971, 0200) provide detailed descriptions of the various ash flow and ash fall layers at the mesita. Three of the boreholes on the mesa are of sufficient depth to penetrate formations underlying the Bandelier Tuff.

The hydrologic characteristics and conditions of the soil, tuff, and material used to cover the wastes indicate no recharge to the stream-connected aquifer in the canyon south of the mesa or to the main aquifer through the soil, buried wastes, or tuff at Mesita del Buey (Purtymun and Kennedy 1971, 0200).

2.6.3.3.2 Fracture Orientation Patterns

The most prevalent structural features in the rocks of Mesita del Buey are the fractures or joints in the volcanic rocks caused by shrinkage during cooling. Purtymun and Kennedy (1971, 0200) describe the suite of joint patterns found on the mesa. They conclude that the heterogeneous characteristics of the tuff (varying temperatures and moisture content of the ash, etc.) are the cause of the multiple fracture patterns in the tuff.

Investigations of the subsurface at Areas G and L have also provided descriptions of jointing in the tuff. Purtymun et al. (1978, 0207) drilled a number of horizontal core holes beneath a waste disposal pit at Area G (Section 2.6.3.6.6). The borings encountered near-vertical joints at frequencies ranging from about 3 to 6 ft in recovered core. Most of the joints were filled or plated with brown clay. Many of the drillholes sunk by Bendix Field Engineering Corp. encountered similar conditions, in which the fractures were partially or completely filled with caliche, brown clay, or limonitic material (Rush and Dexter 1985, 0397).

2.6.3.3.3 Moisture Studies

Abrahams et al. (1961, 0015) studied moisture relationships of the Bandelier Tuff on Mesita del Buey during the late 1950s and 1960s. They measured the physical properties (density, porosity, etc.) and hydrologic properties (permeabilities, moisture tension curves, etc.) of tuff samples and conducted field experiments to investigate infiltration under high-moisture conditions. Data on the natural moisture conditions in the tuff were also collected, which showed values of 5 to 10% by volume below a depth of a few meters.

Purtymun and Kennedy (1971, 0200) show that variable amounts of precipitation percolate through the tuff and soil. Where the soil has not been disturbed, little if any water from precipitation has infiltrated the underlying tuff. Where the soil has been disturbed, as in the waste disposal areas, the moisture content of the tuff indicates a much higher degree of infiltration than it does in the undisturbed tuff. Infiltration studies in the disturbed tuff that composes the pit overburden show that moisture

from a single storm may reach depths nearing 6.5 ft but that, in subsequent weeks, it is returned to the atmosphere by evaporation.

Abeele (1978, 0001) used a neutron moisture probe to monitor the moisture content of fill material overlying waste disposal pits and solid tuff in a field of disposal shafts. In the fill material, the data show significant seasonal fluctuations in moisture content to a depth of 13 ft and a downward moisture flux below that depth. In the solid tuff, the data also show seasonal fluctuations in moisture content in the upper 13 ft but no significant changes below that depth.

2.6.3.3.4 Tritium Migration Studies

Migration of tritium from wastes deposited at Area G was detected as early as 1970. One study showed that the tritium concentration in the tuff around an unlined shaft (Number 13, Area G) increased to a maximum between depths of 10 and 30 ft and then decreased again with depth (Purtymun 1973, 0191). The pattern of tritium concentrations in the subsurface indicated that open joints in the tuff influence migration and provide a pathway for migration of tritiated water in the vapor phase. Additional studies (Abeele et al. 1981, 0009) indicate that tritium also migrates from asphalt-lined shafts into adjacent soils. In both studies, tritium activity decreases logarithmically with distance from the shaft.

2.6.3.3.5 Horizontal Hole Study

Purtymun et al. (1978, 0207) collected samples for radiochemical analysis along horizontal core holes beneath Pit 3 in Area G. A drill pad was constructed in a small canyon east of the pit, and five horizontal holes were cored under the pit. The analytical results from samples obtained beneath the pit were then compared statistically with the analytical results from samples obtained beside the pit. The results showed conclusively that the manmade radionuclides known to be present in the pit were not present at concentrations above the minimum detection limits in the samples collected beneath the pit. There were no statistically significant differences in gross alpha or gross beta radiation or in individual radionuclide concentrations between the sampling locations.

2.6.3.3.6 Vadose Zone Studies

In 1985, detailed vadose zone characterization studies were undertaken in Areas G and L to permit quantitative analysis of moisture movement and chemical characterization of the Bandelier Tuff (IT Corporation 1987, 0327). The investigators used a two-tiered approach to quantify moisture movement in the tuff: (1) measurements of rock characteristics and hydraulic head to calculate seepage velocity and rates of moisture flux and (2) measurement of moisture content of the tuff after precipitation events to determine changes in moisture content with depth.

Eighteen 100- to about 135-ft-deep boreholes were drilled into the Bandelier Tuff from the top of Mesita del Buey, and approximately 1,700 ft of core were obtained. Selected core samples were analyzed for numerous parameters, and hydrologic testing and geophysical logging were performed in the boreholes. Selected boreholes were completed for pore gas sampling, neutron moisture probe monitoring, and psychrometer installation. In addition, holes were drilled in the adjacent canyons to determine whether an alluvial aquifer was present under Mesita del Buey.

The combination of very low moisture content in the tuff, empirical determination that moisture from precipitation does not infiltrate below a depth of 10 to 22 ft, and very low calculated flux rates suggests that aqueous transport of contaminants through Bandelier Tuff is not a viable mechanism for contaminant migration at Areas G and L (Rush and Dexter 1985, 0397). Calculated maximum downward flux rates for Areas G and L were 0.25 and 0.49 ft/yr, respectively.

2.6.3.3.7 Organic Plume Migration Studies

In 1985 and 1986, seven test locations were selected for core and pore gas analyses of the Bandelier Tuff at Mesita del Buey. One background hole was selected at the western end of the mesa. Of the remaining six test holes, two were located at Area G and four at Area L.

The results indicate that volatile organic waste constituents have migrated from land disposal units at Areas G and L (Devaurs 1985, 0046; Devaurs and Bell 1986, 0048). Volatile organic vapors have been detected at depths up to 100 ft. The highest pore gas concentrations of volatile organic compounds have been detected in the test holes nearest the organics disposal shafts at Area L. Organics are more likely to migrate in the vapor phase than in the aqueous phase. Metal contamination from the land disposal units at Areas G and L was detected in only two samples from shallow depths (20 ft or less) at Area L (Devaurs 1985, 0046).

2.6.3.4 Area P

The monitoring described below is currently being conducted in support of interim status closure and postclosure care plans at the landfill in Area P, TA-16. These data are presently being summarized in a final report. Other investigations, including an area geological characterization (Brown et al. 1988, 0034) and a water balance study (Nyhan 1989, 0154), summarize historical site conditions.

The vadose-zone-monitoring system, consisting of eight separate wells clustered in four well nests, was installed in and below the Area P landfill during the fall of 1988. Each well nest consists of either a single- or dual-completion pressure-vacuum lysimeter borehole and an adjacent neutron moisture probe access well. The four lysimeter boreholes contain a total of seven independent lysimeters located at varying depths in and below the landfill; the neutron access wells penetrate the underlying native Bandelier Tuff to a maximum depth of 30 ft.

Core samples of soil and tuff collected during these installations have been analyzed for landfill-related contamination. In addition, four of the seven lysimeters have yielded small volumes of water at routine sampling intervals over a 1-year period; all of these lysimeters are adjacent to the landfill. The three remaining lysimeters that did not yield water are all located below the contact of the landfill and tuff. Monthly measurements of neutron moisture taken at the access well have shown a consistently stable moisture distribution in four landfill access wells and five perimeter access wells. However, volumetric moisture contents typically vary between individual wells and over depth. Detailed analyses of these vadose-zone-monitoring data will assist in evaluating current site conditions and will be summarized in a final report.

2.6.3.5 Frijoles Mesa

2.6.3.5.1 Hydrogeologic Study

In 1959 and 1960, before the Laboratory began hydronuclear experiments involving radioactive and high-explosive materials at TA-49, the USGS performed a detailed geologic and hydrologic investigation of Frijoles Mesa between Ancho and Water canyons (Appendix C). The USGS investigations were conducted in large (3- and 6-ft-) diameter test holes at depths ranging from 30 to 120 ft below ground surface. The hydrogeologic investigation of the mesa consisted of geologic mapping, performing subsurface geologic studies, interpreting geophysical logs of holes, conducting pumping tests, and measuring water level and soil moisture in boreholes.

The investigators concluded that "recharge to the ground water from Frijoles Mesa is very small or nonexistent; thus no contaminants in solution are likely to be carried to the ground water beneath TA-49" (Weir and Purtymun 1962, 0228). Data from three deep test wells indicated that the top of the main aquifer near the center of the experimental areas was at a depth of about 1,170 ft. Geologic examination revealed that no perched water is present. The absence of perched water and moisture in test holes indicates that water rarely infiltrates the mesa surface to depths greater than the thickness of the soil (Weir and Purtymun 1962, 0228).

Groundwater quality has been monitored routinely since the time the experiments were initiated (Appendix C). The measurements confirm that there has been no contamination of groundwater (Purtymun and Stoker 1987, 0204).

2.6.3.5.2 Hole Examinations

As a part of its investigation, the USGS collected rock samples and sent them to USGS laboratories for petrographic description, chemical and x-ray analysis, and measurement of physical properties. Rock samples have been stored in archives for future study, and large- (3- and 6-ft-) diameter test holes have been photographed for future reference.

2.6.3.5.3 Moisture Movement Studies

To measure moisture, the USGS drilled 23 access holes ranging from 10 to 49 ft deep from the surface of the mesa. Soil thickness was measured and mapped. The holes were logged with a neutron probe to determine the moisture content of the soil and tuff near the mesa surface. The studies indicated little if any movement of precipitation into the tuff underlying the soil cover (Abrahams et al. 1961, 0015). The natural moisture content of the tuff ranges from less than 4% to about 8% by volume, indicating that movement of water could occur only by diffusion in the vapor phase. Weir and Purtymun (1962, 0228) concluded that the soil cover "...forms an almost perfect seal over the mesa surface and the near-surface joints."

2.6.3.5.4 Special Monitoring

In 1961, the Laboratory undertook, in cooperation with the USGS, a program of environmental surveillance of TA-49, which the Laboratory has conducted alone

since 1970. This surveillance includes analyzing sediment and surface run-off, measuring water levels, and sampling the water in the main aquifer via wells and springs. Measurements confirm that there has been no contamination of groundwater. Minor plutonium contamination of the surface soil dating from the time of hydronuclear experiments has been detected in small surface drainages near the experiment area (Purtymun and Stoker 1987, 0204).

In 1975, routine monitoring at the site detected the presence of about 50 ft of water in the bottom of Core Hole 2, located adjacent to hydronuclear Test Hole 2-M. Analysis of water samples from the core hole showed the presence of plutonium, indicating that water had moved plutonium from the experimental hole into the core hole.

Concern relating to the presence of water in the core resulted in a special hydrologic investigation in 1980 to locate the source of the water to determine whether it resulted from infiltration through a broken asphalt surface above Test Hole 2-M or whether water was moving into the tuff beneath the experiment area on a larger scale. Plutonium and moisture contents were evaluated in test borings, and it was determined that the water in the core hole came through the asphalt surface cover (Purtymun and Stoker 1987, 0204). The hole was bailed dry in 1980 and remained dry through 1986, the time of the last inspection.

2.6.4 Geohydrology of Canyon Surface Waters and Alluvial Aquifers

2.6.4.1 General Conditions

Figure 2-5 shows the location of the major surface water drainages in the Los Alamos area. In the Los Alamos area, surface water occurs primarily as ephemeral streams. Springs on the flanks of the Jemez Mountains supply base flow in the upper reaches of some of the canyons that extend through Laboratory lands; perennial flow occurs in the upper reaches of Cañon de Valle and Los Alamos, Pajarito, and Water canyons (Appendix C) (Purtymun 1975, 0194). The amount of discharge is insufficient to maintain surface flow across the Laboratory site before depletion by evaporation, transpiration, and infiltration. Surface flow can occur for more than a mile as the result of releases from industrial waste treatment plants, sanitary sewage, and cooling tower blowdown. Several times a year, run-off from heavy thundershowers and heavy snowmelt reaches the Rio Grande.

All of the canyons on the Pajarito Plateau contain alluvium that is quite permeable, ranging in thickness from 3 to 100 ft. Only canyons that originate in the Sierra de Los Valles (Figure 2-4) or that receive significant quantities of industrial effluent have alluvial aquifers. These criteria are met in lower Pueblo, Los Alamos, Mortandad, and Pajarito canyons (Appendix C). Water infiltrates through the alluvium until the downward movement is impeded by the less permeable tuff and sediments. Depletion by evapotranspiration and movement into the underlying volcanics limits the horizontal and vertical extent of the alluvial aquifers (Purtymun et al. 1977, 0206).

2.6.4.2 Bayo Canyon

Bayo Canyon originates on the Pajarito Plateau and is tributary to the lower reach of Los Alamos Canyon (Appendix C). It has a drainage area of 33.8 mi^2 and an average slope of 0.03. The canyon cuts into the Bandelier Tuff, the Puye Formation,

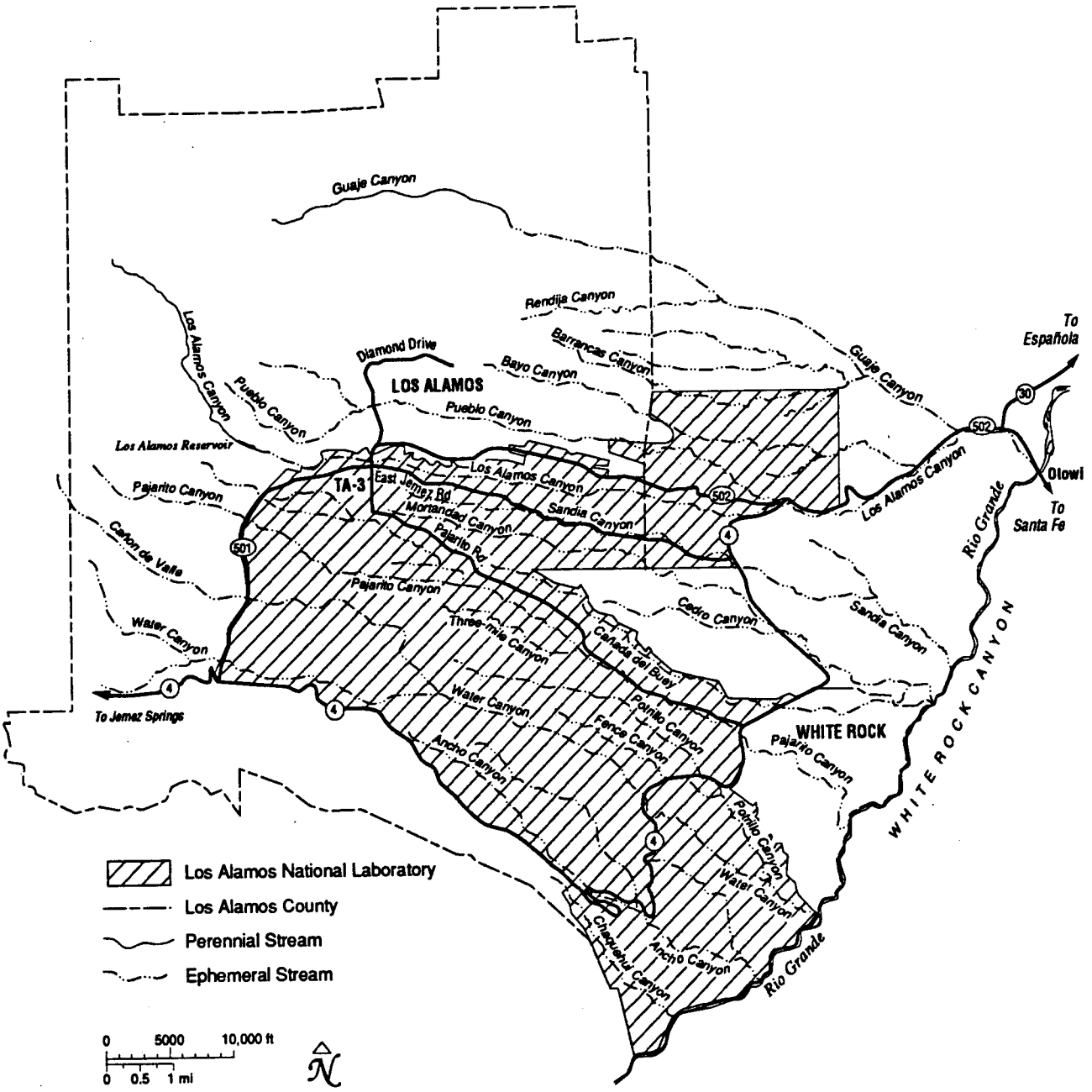

Figure 2-5. Location of major suface water drainages in the Los Alamos area.

and the Tesuque Formation. The flow in the canyon is ephemeral, and most of the run-off is caused by heavy summer thundershowers. The run-off generally lasts no longer than several hours (Purtymun 1975, 0194; 1979, 0371). There are no gaging stations in this canyon.

In 1961, three test holes were drilled in Bayo Canyon to determine whether water occurred in the alluvium or in the tuff at the Puye Formation contact. The test holes indicated no water in the channel alluvium or perched in the tuff. Three test holes were drilled in 1973, and 12 test holes were drilled in 1974; all were dry. These results indicate that the movement of contaminants by groundwater in Bayo Canyon is very unlikely (Purtymun 1979, 0371).

2.6.4.3 Pueblo Canyon

Pueblo Canyon originates on the flanks of the Sierra de Los Valles and has cut a deep canyon into the Pajarito Plateau (Appendix C). It drains 8.6 mi^2.

2.6.4.3.1 Surface Water and Sediments

Release of treated sewage effluent from the Bayo treatment plant causes perennial streamflow in the lower reaches of Pueblo Canyon. Run-off from winter snowmelt and summer thunderstorms adds to the volume of flow. From 1951 through 1963, industrial effluents from the Laboratory treatment plant at TA-45 were released into Acid Canyon, a tributary to Pueblo Canyon. A former industrial waste water treatment plant released effluents into the middle reach of the canyon from 1947 through 1966. Measurements of flow in Pueblo Canyon and a history of effluent discharge are provided by Weir et al. (1963, 0395), Abrahams (1966, 0013), Abrahams and Purtymun (1966, 0014), Purtymun (1975, 0194), and LANL (1981, 0141). Sediment discharges are reported by Purtymun et al. (1990, 0215). Run-off events have redistributed sediments from Pueblo Canyon into lower Los Alamos Canyon, and this transport is likely to continue. No major flooding events have occurred in Pueblo Canyon during the last 40 years.

Current streamflow in Pueblo Canyon consists primarily of sewage effluent; therefore, the chemical quality of the surface water is determined by this source (Weir et al. 1963, 0395; Abrahams 1966, 0013; Abrahams and Purtymun 1966, 0014; Purtymun 1975, 0194; ESG 1976–1989). From 1943 through 1951, untreated effluent containing radionuclides—mainly plutonium, uranium, tritium, and fission products—was released into Acid Canyon. Treated radioactive wastes were released into Pueblo Canyon from the treatment plant at TA-45 between 1951 and 1964. The quality of surface water has been reported since monitoring began in 1945 (Weir et al. 1963, 0395; Abrahams 1966, 0013; Abrahams and Purtymun 1966, 0014; Purtymun 1975, 0194; LANL 1981, 0141; ESG 1971–1989).

Concentrations of radionuclides in surface water and sediment decreased as the treatment plants began to operate. In addition, radionuclide concentrations in the canyon generally decrease downstream from the effluent outfalls because sediments in the stream channels adsorb the radionuclides and the sediments disperse (Weir et al. 1963, 0395; Abrahams 1966, 0013; Abrahams and Purtymun 1966, 0014; Purtymun 1975, 0194; LANL 1981, 0141; Nyhan et al. 1980, 0162). Most of the radioactively contaminated sediments lie in lower Pueblo Canyon. Dose calculations indicate that the dose received from the sediments would slightly exceed the dose received from background levels (LANL 1981, 0141).

From 1949 to 1967, the USGS studied the effects of the release of industrial effluents on the environment and geohydrology (Weir et al. 1963, 0395; Abrahams 1966, 0013; Abrahams and Purtymun 1966, 0014; Purtymun 1966, 0184; 1966, 0186; Purtymun and Enyart 1966, 0198; Purtymun and Kunkler 1967, 0202; 1969, 0202; LANL 1981, 0141). Environmental data gathered subsequently by the Laboratory are summarized in a series of reports issued from 1967 through the present (ESG 1971–1989). Chemical and radiochemical analyses show that drinking water standards for chemical and radiochemical constituents are exceeded; however, this water is not used for municipal, agricultural, or industrial supply.

An extensive field monitoring and sampling program to evaluate the radiological conditions in Acid and Pueblo canyons was conducted during 1976 and 1977 as part of the Formerly Utilized Sites Remedial Action Program sponsored by the DOE. This study reviewed historical records and used new sampling methods to obtain data. It considered potential radiation exposure under current and future conditions and maximum doses (LANL 1981, 0141). Residual radioactivity was found on sediments, although the indicated dose to the public was found to be small (LANL 1981, 0141).

A number of investigators have studied the distribution of radionuclides in channel sediments and radionuclide transport in snowmelt run-off (Purtymun et al. 1990, 0215). The USGS has conducted seepage runs for discharge measurements (Abrahams and Purtymun 1966, 0014). Purtymun et al. (1988, 0213) sampled surface and groundwaters for organics from pesticides and other sources. Snowmelt run-off was found to carry plutonium, primarily in the sediment fraction. Concentrations of plutonium were low. Volatile organics, base neutral acid, and cyanide were detected in a few instances. No semivolatile organics, pesticides, herbicides, or PCBs were detected.

2.6.4.3.2 Alluvial Aquifer

The streamflow in Pueblo Canyon recharges a shallow body of groundwater in the alluvium. As the water in the alluvium moves downgradient, water is lost to evapotranspiration and through recharge into two shallow perched water bodies in the Puye Formation and the basaltic rocks of the Chino Mesa Formation (Purtymun 1975, 0194).

From 1954 to 1965, the USGS installed 14 shallow wells and collected samples (Weir et al. 1963, 0395; Abrahams and Purtymun 1966, 0014; Purtymun 1966, 0184; 1966, 0186; Purtymun and Enyart 1966, 0198; Purtymun and Kunkler 1967, 0202). Storm run-off destroyed most of the wells. In 1965, sampling of the alluvial aquifer was discontinued because of the great chemical and radiochemical similarity of surface and groundwater. Sampling was resumed in 1990 to study inorganic and organic compounds, heavy metals, and pesticides, which had not been investigated earlier.

Special studies of the alluvial aquifer consist of reconnaissance sampling for organics, pesticides, and herbicides (Purtymun et al. 1988, 0213). The studies were performed by sampling only the surface water, because the compositions of the surface and groundwater were similar.

2.6.4.4 Los Alamos Canyon

2.6.4.4.1 Surface Water and Sediments

Los Alamos Canyon drains a 10.6-mi^2 area that extends from the divide on the Sierra de Los Valles down to the Rio Grande near Otowi Bridge (Appendix C). Its major tributaries are Pueblo Canyon near the eastern edge of the plateau and DP Canyon near the center of the plateau. Perennial surface flow occurs in the upper reaches and is partially impounded by Los Alamos Reservoir. Surface flow in the middle and lower reaches is intermittent. Some cooling tower and sewage effluents are released from TA-2 and TA-41. During the summer, storm water run-off occasionally reaches the Rio Grande. In some years, snowmelt run-off also reaches the Rio Grande. Streamflow in DP Canyon is intermittent, consisting of industrial and sanitary effluents and storm water run-off.

Discharge measurements collected by the USGS (Abrahams and Purtymun 1966, 0014) and the Laboratory (Purtymun 1974, 0193; Purtymun 1975, 0194) have been reported. Two stream gages are located in Los Alamos Canyon and one in DP Canyon. Discharge of flow and sediment load for snowmelt run-off is reported by Purtymun et al. (1990, 0215). Purtymun (1975, 0194) describes sediment discharge. Summer run-off and snowmelt discharge were found to carry radionuclides in solution as well as in sediment.

Water quality measurements of surface water were collected as early as 1952 (Purtymun 1975, 0194) and continue today as part of the annual environmental surveillance program (LANL 1981, 0141; ESG 1971–1989). Samples at two surface water stations and at the Los Alamos Reservoir are analyzed for radiochemical and chemical constituents, and the results are reported annually (ESG 1971–1989). The results of radiochemical analyses from 11 soil-sampling stations in Los Alamos and DP canyons are reported in the annual surveillance report. Radionuclide concentrations decrease downgradient in the canyon because of dilution and absorption by alluvial sediments.

Special studies that have been conducted in Los Alamos and DP canyons include investigations of radionuclide transport in run-off by Purtymun (1974, 0193; 1966, 0184; 1966, 0186); Hakonson and Bostick (1976, 0315); and Purtymun et al. (1990, 0215). Investigations for organics, pesticides, and herbicides have been performed (Purtymun et al. 1988, 0213). Measurements taken between 1975 and 1986 show that plutonium has been transported into the Rio Grande from snowmelt run-off. None of these studies detected organic compounds, pesticides, or herbicides in the Rio Grande at its confluence with Los Alamos Canyon.

2.6.4.4.2 Alluvial Aquifer

The surface water in Los Alamos Canyon consists of sanitary sewage effluent, cooling tower blowdown, storm and snowmelt run-off, and inflow of water from the alluvium in DP Canyon. The surface water recharges alluvial water perched on the tuff. As the water in the alluvium moves downgradient, some is lost to evaporation, transpiration, and vertical movement into the underlying tuff, conglomerate, and basalts. Alluvial water extends from the upper reaches of Los Alamos Canyon down to a point near its confluence with DP Canyon.

DP and Los Alamos canyons have received treated industrial effluents that contain some radionuclides. Six observation holes located along the length of Los Alamos Canyon are sampled for chemical and radiochemical water quality (Appendix C). The results are reported annually in the Laboratory's annual environmental surveillance report (ESG 1971–1989). The shallow groundwater contains measurable but low amounts of radioactivity.

Purtymun et al. (1990, 0215) have studied the loss of groundwater from the alluvial aquifer into the underlying tuff, have determined surface water data from transport of plutonium during snowmelt run-off, and have estimated snowmelt losses in the channel. They have also calculated storage in the alluvial aquifer and have estimated losses into the underlying tuff and volcanic rocks. Sampling for organics, pesticides, and herbicides has been performed (Purtymun et al. 1988, 0213). The alluvial aquifer is recharged by streamflow. In a few instances, volatile organics, semivolatile organics, and base neutral acids were found in the shallow groundwater.

2.6.4.5 Sandia Canyon

Sandia Canyon has a small (2.7-mi^2) drainage area that originates on the Pajarito Plateau in TA-3 (Appendix C). The canyon receives cooling tower blowdown from the TA-3 power plant and treated sanitary effluents from the sanitary waste treatment plant at TA-3. The treated effluents form a perennial stream in a short reach of the upper canyon. Only during heavy summer thundershowers in the drainage area does streamflow reach the Laboratory boundary at State Road 4. Two monitoring wells in the lower canyon west of State Road 4 indicate no perched water in the alluvium in this area. Three surface-water-sampling stations are located in the reach of the canyon that contains perennial flow. The samples are analyzed for radiochemical and chemical constituents and are reported in the Laboratory's annual environmental surveillance reports (ESG 1971–1989). Samples of surface waters have been analyzed for organics, pesticides, and herbicides (Purtymun et al. 1988, 0213). Measurable amounts of radioactivity have been detected in the surface water; cyanide has also been detected, but no organic compounds have been found.

2.6.4.6 Mortandad Canyon

Mortandad Canyon drains a 1.8-mi^2 area west of the Los Alamos County line and is located entirely on the Pajarito Plateau (Appendix C). An industrial waste treatment plant at TA-50 collects and processes liquid wastes containing radionuclides. After treatment, which removes most of the radioactivity, the effluents are released into Mortandad Canyon.

Hydrologic studies began in 1960 before the time the waste treatment plant at TA-50 began to operate. Since that time, there has been no surface flow in Mortandad Canyon beyond the Laboratory's boundary because the small area drained by the canyon produces little run-off and a thick section of unsaturated alluvium in the lower canyon permits rapid infiltration and storage of effluent and run-off. This alluvial aquifer extends up to 130 ft below the ground surface. Monitoring stations include one surface-water-monitoring station and six observation wells in the shallow alluvial aquifer (Appendix C). The wells in the lower reaches of the canyon are dry.

2.6.4.6.1 Surface Water and Sediments

The USGS conducted preoperational studies of streamflow to establish the background surface flow conditions before the installation of the TA-50 radioactive waste treatment plant (Baltz et al. 1963, 0024; Purtymun 1964, 0183). After operations had begun, a stream gage was installed, and discharge studies continued (Purtymun 1967, 0188; Purtymun and Kunkler 1967, 0202). Hakonson (1981, 0314) has studied sediment transport.

Environmental monitoring for chemical and radiochemical quality in surface water began with USGS investigations (Purtymun 1964, 0183; 1967, 0188; Purtymun and Kunkler 1967, 0202; Purtymun 1975, 0194) and have been continued by the Laboratory (ESG 1970–1986). Radioactivity and elevated nitrate concentrations are present as a result of the effluent discharged into this canyon.

Special studies of plutonium in surface water and in sediments have been conducted (Purtymun 1975, 0194; Purtymun et al. 1977, 0206; Purtymun 1971, 0190; Hakonson et al. 1979, 0119; Hakonson 1981, 0314; Nyhan et al. 1976, 0160). Purtymun et al. (1988, 0212) have studied organic compounds in groundwater. Studies performed in 1979 sampled channel and bank sediments and vegetation for chemical constituents along the stream channel from the waste outfall at TA-50 to a distance of 10,000 ft (Ferenbaugh and Gladney, in preparation, 0427).

2.6.4.6.2 Alluvial Aquifer

Perennial flow from industrial and sewage effluents and intermittent storm and snowmelt run-off recharge a small body of water in the alluvium, which is perched on the underlying tuff. As the water in the alluvium moves eastward, steady losses to evapotranspiration and minor losses into the tuff occur, limiting the amount of water in the alluvium. The alluvial aquifer does not extend beyond the surface water discharge boundary at the Los Alamos/Santa Fe county line (Appendix C).

The USGS conducted a preliminary study of the geology and hydrology of the alluvial aquifer in 1960 and 1961 (Baltz et al. 1963, 0024), which was followed by USGS and, later, by Laboratory studies (Abrahams et al. 1962, 0231; Purtymun 1964, 0183; Purtymun 1967, 0188; Purtymun 1975, 0194; Devaurs and Purtymun 1985, 0049). Thirteen observation wells collect information on groundwater level and chemical and radiochemical quality (Appendix C).

The USGS began environmental monitoring of alluvial water with preoperational surveys of chemistry and radiochemistry (Purtymun 1964, 0183). Environmental monitoring of the chemistry and radiochemistry of alluvial water continued under the USGS (Purtymun and Enyart 1966, 0198; Purtymun 1967, 0188; Purtymun 1967, 0188; Purtymun 1969, 0189) and by the Laboratory (Purtymun 1975, 0194; ESG 1971-1989). The shallow groundwater contains elevated levels of radioactivity and nitrates because of the waste effluent discharged into this canyon. The aquifer lies entirely within Laboratory boundaries.

Numerous special studies have been conducted on the water quality of this shallow aquifer. Tritium and chloride concentrations have been used to calculate the rate of water movement in the aquifer. Using the resulting data, investigators have determined the aquifer's permeability and storage capacity and have inventoried its chemical constituents and radionuclides (Purtymun 1973, 0191; 1974, 0192; Purtymun

et al. 1984, 0210). Concentrations of radionuclides decrease downgradient from the waste outfall. Some radionuclides have migrated into the tuff underlying the alluvial aquifer.

Purtymun and others have also performed radiochemical studies (Purtymun et al. 1983, 0209; 1984, 0210) and chemical studies (Purtymun 1975, 0194; 1988, 0213, Purtymun et al. 1977, 0206). The samples collected were analyzed for organics, pesticides, and herbicides (Purtymun et al. 1988, 0213). Cyanide was detected, but there were no organic compounds in the groundwater.

2.6.4.6.3 Extent of Saturation in Mortandad Canyon

A recent special study evaluated the extent of saturation in Mortandad Canyon; the occurrence of radioactive, inorganic, and organic contaminants in the perched alluvial water in the bottom of the canyon; and the unsaturated tuff beneath the saturated alluvium (Stoker et al. 1991, 0715). The study was conducted in part to comply with a special condition of the HSWA Module (EPA 1990, 0306)

The saturated aquifer is of limited extent because the recharge is sufficient only to maintain a saturated zone in the alluvium extending about 2.2 mi downstream from the TA-50 outfall. Saturation extends eastward from the outfall to within about a mile of the Laboratory boundary. Test holes drilled or cored through the alluvium indicate that the underlying tuff is not saturated. Moisture content generally declines to less than 50% of saturation, both transverse to the canyon axis and at depth.

Generally more than 99% of the residuals from the treatment plant effluents are associated with sediments in or immediately adjacent to the stream channel. A small fraction of the residuals, on the order of 1% or less, are present in the perched water in the alluvium. Except for tritium, radioactive constituents have apparently moved less than about 10 ft into the unsaturated zone. Tritium, as tritiated water, has moved to depths of at least 195 ft in the tuff.

2.6.4.7 Cañada del Buey

Cañada del Buey originates on the Pajarito Plateau. It drains a 3.4-mi^2 area and lies entirely in the Bandelier Tuff (Appendix C). Streamflow in the canyon is intermittent. One small stretch near TA-46 receives cooling tower blowdown. The alluvium in the canyon is quite thin and contains no water (IT Corporation 1987, 0327; Devaurs and Purtymun 1985, 0049).

Since 1973, the Laboratory has sampled the radiochemical and chemical content of the surface waters in Cañada del Buey as part of a routine environmental program (ESG 1974, 0094). Limited radiochemical sampling has been performed in sediments (Purtymun 1975, 0194). Since 1982, the Laboratory has routinely monitored stream sediments for radionuclides (ESG 1983-1989) and for hazardous and toxic constituents (Purtymun and Maes 1987, 0203; 1988, 0372). Although sediments transport some cesium and plutonium from the active waste management area at TA-54, radionuclide concentrations in sediments were not detectable at the Laboratory boundary at State Road 4. Organic compounds 1,1,2,2-tetrachloroethane and 1,1,1,2-tetrachloroethane were detected in sediments in Cañada del Buey at State Road 4. No metals, pesticides, or herbicides were measured above the limits of detection.

2.6.4.8 Pajarito Canyon

Pajarito Canyon originates on the flanks of the Sierra de Los Valles and drains an area of 10.6 mi^2 (Appendix C). The stream channel is cut into the Bandelier Tuff across the Pajarito Plateau. Streamflow in the canyon is ephemeral and results from storm run-off and snowmelt. This ephemeral flow moves downgradient and recharges the alluvium overlying the tuff (Purtymun and Kennedy 1971, 0200). The alluvial water in Pajarito Canyon is confined to the alluvium in the canyon and does not extend horizontally or vertically under Mesita del Buey (Devaurs and Purtymun 1985, 0049; IT Corporation 1987, 0327). A minor amount of treated sewage effluent is released into the canyon below TA-18.

Since 1973, the Laboratory has routinely sampled surface water for chemical and radiochemical constituents (ESG 1974, 0094). Purtymun (1975, 0194) provides limited data on radiochemical and chemical surface water data and radiochemical analyses of sediment. Beginning in 1986, stream sediments have been analyzed for hazardous and toxic constituents (Purtymun and Maes 1987, 0203; 1988, 0372). Radiochemical and chemical concentrations in alluvial water showed no effect from Laboratory operations. Analyses of sediments collected at the Laboratory boundary at State Road 4 showed no elevation in radionuclide concentrations. Results of analyses of sediments for metals, pesticides, and herbicides were below the limits of detection. The compound 1,1,2,2,-tetrachloroethane was detected in sediments in Pajarito Canyon at the Laboratory boundary at State Road 4.

2.6.4.9 Potrillo Canyon

Potrillo Canyon originates on the Pajarito Plateau and drains an area of about 2.4 mi^2 upstream of State Road 4 (Appendix C). The stream channel is cut into the Bandelier Tuff. The ephemeral streamflow in the canyon results from thunderstorms and snowmelt. Potrillo Canyon drains five firing (explosives detonation) sites; consequently, depleted uranium from testing activities is found in the watershed. Studies have been made to characterize uranium concentrations in sediments (Hanson and Miera 1977, 0128; 1978, 0129) and to determine transport of uranium through run-off mechanisms (Becker et al. 1985, 0029; Becker 1986, 0027). The Laboratory began routinely monitoring radionuclides in sediments in 1977 (ESG 1978-1989). Monitoring for hazardous and toxic constituents in sediments began in 1986 (Purtymun and Maes 1987, 0203; 1988, 0372). Levels of uranium in solution and in suspended sediments in run-off samples are within background concentrations at State Road 4. The compound 1,1,2,2-tetrachloroethane was detected in sediments at the Laboratory boundary at State Road 4. Levels of metals, pesticides, and herbicides were below the limits of detection.

2.6.4.10 Water Canyon

Water Canyon originates on the flanks of the Sierra de Los Valles, where it has cut canyons into the Tschicoma Formation and the Bandelier Tuff. Where it crosses the Pajarito Plateau, it cuts into the Bandelier Tuff. Along the eastern edge of the plateau near the Rio Grande, the canyon is cut into the basalts of the Chino Mesa and underlying Tesuque Formation. Cañon de Valle is tributary to Water Canyon in the upper reach, and Fence and Potrillo canyons are tributary south of State Road 4. Water Canyon drains an area of 12.8 mi^2 (Appendix C). Perennial flow occurs in the upper reaches, and waste water from S-Site is released to the canyon, also in the

upper reaches. Streamflow moves into the alluvium for a short distance. In the remainder of the canyon, streamflow is ephemeral and results from storms and snowmelt.

Routine radiochemical analyses of surface water in Water Canyon are performed as part of annual environmental monitoring activities that began in 1973 (ESG 1974, 0094) and continues today. Purtymun (1974, 0192) provides some earlier data on the chemical and radiochemical components of surface water and on the radiochemical components of sediments. Beginning in 1977, the Laboratory's annual environmental monitoring program included studies of the radiochemistry of sediments in Water Canyon (ESG 1978-1989). Some heavy metals in the canyon have been investigated (Kasunic et al. 1985, 0134; Becker 1986, 0027). Radionuclide concentrations in sediments are at background levels. Radionuclide concentrations in surface water are at the limits of detection (ESG 1989, 0308). The compounds 1,1,2,2-tetrachloroethane and 1,1,1,2-tetrachloroethane were detected in sediments in Water Canyon at State Road 4, and some nickel was reported in sediments from Fence Canyon at State Road 4. No pesticides or herbicides were detected in Water Canyon or in its tributary canyons.

2.6.4.11 Ancho Canyon

Ancho Canyon originates in the middle of the Pajarito Plateau (Appendix C). The canyon is cut into the Bandelier Tuff on the plateau and through the basalts of the Chino Mesa and the Tesuque Formation on the eastern edge of the plateau as the channel drops into the Rio Grande. Stream flow on the plateau is ephemeral, although, in the lower reaches of the canyon, perennial flow originating from springs in the Totavi Lentil reaches the Rio Grande. Probably some small volumes of alluvial water occur seasonally in the upper reach of the canyon (Purtymun 1975, 0194).

In 1977, the annual environmental monitoring program began sampling sediments in Ancho Canyon for radiochemical constituents (ESG 1978, 0095), and this program continues today. Beginning in 1977, spring flow in Ancho Canyon was sampled for chemical and radiochemical constituents (ESG 1978-1989, Purtymun et al. 1980, 0208). Special studies have included sediment sampling for depleted uranium (Becker et al. 1985, 0029), plutonium (Purtymun et al. 1987, 0211), and radionuclide and chemical components of sediments (ESG 1989, 0308). Radiochemical constituents in water and sediments and chemical constituents in sediments are within background values.

2.6.4.12 Chaquehui Canyon

Chaquehui Canyon originates in the eastern part of the Pajarito Plateau (Appendix C). It drains an area of 1.8 mi^2 and cuts into the Bandelier Tuff and through the basalts of the Chino Mesa and the Tesuque formations as the channel drops steeply into the Rio Grande. Little to no alluvium occurs in the upper or middle reaches of the canyon. Streamflow in the canyon is ephemeral. Near the eastern end of the canyon, above the Rio Grande, water from springs and seeps in the Tesuque Formation (main aquifer) maintains a small stream and several large pools that infiltrate into the alluvium before the water reaches the Rio Grande. These springs have been sampled annually as part of the routine environmental monitoring program (ESG 1978-1989, Purtymun et al. 1980, 0208). Sediments have been sampled since 1978 as part of the same program (ESG 1979-1989). Cesium, plutonium, tritium, and total

uranium activity in water was low; chemical concentrations were within drinking water standards. Radiochemical concentrations in sediments were also low.

2.6.5 Perched Water

Perched water occurs in conglomerates and basalts beneath the alluvium in a limited area about 120 ft beneath the surface in the midreach of Pueblo Canyon and in a second area about 150 to 200 ft beneath the surface near the confluence of lower Pueblo and Los Alamos canyons. The perched water in these two locations does not connect hydrologically with the main aquifer (LANL 1981, 0141).

The only known body of water perched in the Puye Formation above the main aquifer occurs in the midreach of Pueblo Canyon. The horizontal extent of the aquifer is limited. Changes in water levels over time indicate that the aquifer is hydraulically connected to the streamflow in Pueblo Canyon. The aquifer is sampled annually for chemical and radiochemical constituents (ESG 1977-1989, Purtymun 1975, 0194).

Perched water has been encountered in the basaltic rocks of Chino Mesa in the lower part of Pueblo Canyon, as well as in lower Sandia Canyon. Recharge to the aquifer occurs in the midreach of Pueblo Canyon, as well as in the midreach of Los Alamos Canyon. Surface flow from sanitary waste water from the Bayo treatment plant in Pueblo Canyon and storm run-off in Los Alamos Canyon contribute to the perched water. Water moves eastward, as shown by some discharge from the basaltic rocks at Basalt Springs (Purtymun 1975, 0194). Early surveillance activities by the USGS and later by the Laboratory document the quality of water from these two perched water bodies (Weir et al. 1963, 0395; Abrahams 1966, 0013; Abrahams and Purtymun 1966, 0014; Purtymun 1969, 0189; ESG 1971-1989). The concentrations of chlorides, nitrates, and total dissolved solids in these two perched aquifers have increased. Concentrations of radioactivity are below the limits of detection.

2.6.6 Hydrology of the Main Aquifer

2.6.6.1 General Conditions

The main aquifer of the Los Alamos area is the only aquifer capable of supplying municipal and industrial water. The surface water and groundwater in the alluvium are separated from water in the main aquifer by several hundred feet of unsaturated volcanic tuff and sediments. The upper surface of the main aquifer rises westward from the Rio Grande through the Tesuque Formation beneath the central and western parts of the plateau (Figure 2-6). The water in the aquifer moves from its major recharge area in the Valles Caldera eastward toward the Rio Grande, where a part is discharged into the river through seeps and springs.

The major recharge area for the aquifer is the intermontane basin formed by the Valles Caldera. The upper parts of the sediments in the basin are lacustrine deposits of clay, sand, and gravels, which are underlain by volcanic debris that resulted from collapse of the caldera. The sediments and volcanics are highly permeable and are saturated. The saturated "basin fill" recharges the main aquifer in the sediments of the Tesuque Formation. Minor amounts of recharge may occur in the deep canyons that contain perennial streams on the flanks of the mountains. The ephemeral streams in the canyon, which are cut into the plateau, add little if any recharge to the main aquifer (Purtymun 1984, 0196). Purtymun summarizes general hydrologic

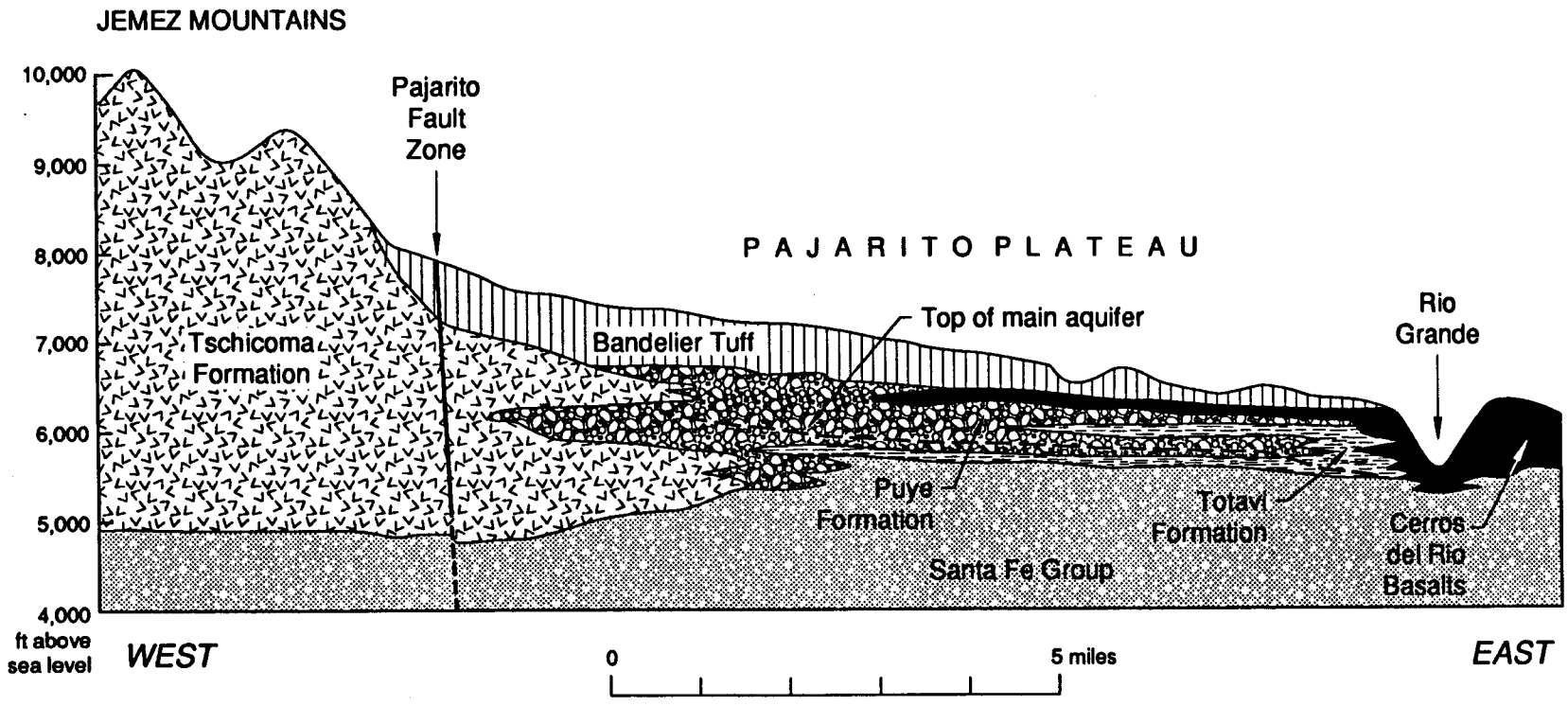

Figure 2-6. Geologic section showing stratigraphy and structure from the Sierra de los Valles across the Pajarito Plateau to the Rio Grande.

characteristics, pumping rates, specific capacities, transmissivities, and field coefficients of permeability as determined during aquifer tests or during periods of production of supply wells and test holes.

2.6.6.2 Water Supply

The Laboratory and the communities of Los Alamos and White Rock are supplied by water pumped from deep wells in three well fields located in Los Alamos Canyon, Guaje Canyon, and on the Pajarito Plateau (Appendix C). These wells draw water from the main aquifer of the Los Alamos area, which lies at depths varying from several hundred to more than 1,000 ft below the mesa tops.

The six original wells in the Los Alamos Field were drilled and completed between 1946 and 1948. An additional well was completed in 1960. Five additional wells completed in 1950 and 1951 form the Guaje Field. Two more wells were added in 1954 and 1965. The Pajarito Field consists of five wells developed between 1965 and 1982. In addition, the original surface water sources still contribute a small part of the Los Alamos water supply. The radiochemical and chemical quality of the supply wells is also described in the Laboratory's annual surveillance reports. Annual reports since 1970 summarize hydrologic data of individual wells from 1948 through 1989 (e.g., Purtymun and Stoker 1988, 0205).

The Laboratory and the communities of Los Alamos and White Rock are supplied by water pumped from deep wells that range in age from 7 to 43 years. The production in these wells has declined significantly in the past few years. Failed attempts to rehabilitate older wells have focused attention on the need for a comprehensive plan to ensure a reliable water supply for the long term.

Purtymun and Stoker (1988, 0205) provide the history, capacity, and production of each well field. They also evaluate the potential for obtaining additional water through new wells by considering the geologic and hydrologic variables in each well field. As a result of this report, two new wells were added to the system in late 1989 and early 1990.

2.6.6.3 Test Wells

Eleven deep test holes have been drilled on the plateau and in canyon locations to investigate the potential for groundwater contamination. The test holes were also used to determine the geologic units, water-bearing formations, and hydrologic properties of the main aquifer. The wells were drilled into the main aquifer in 1949, 1950, and 1960. Seven of the original 11 are sampled for radiochemical and chemical constituents as part of the annual environmental monitoring program reported in the annual environmental surveillance report (ESG 1989, 0308) (Appendix C).

2.6.6.4 Springs in White Rock Canyon

Twenty-seven springs discharge from the Totavi Lentil and the Tesuque Formation in White Rock Canyon (Purtymun 1966, 0187). The water from these springs generally acquires its chemical characteristics from the rock units that compose the spring aquifer. Twenty-two of the springs fall into three groups of similar chemical composition. The five remaining springs make up a fourth group, whose chemical

components differ from those of the first three groups because of localized conditions in the aquifer. These localized conditions may be related to recharge or discharge in or near basalt intrusions or through faults.

The chemical composition of water from individual springs varies slightly in samples collected from 1964 to the present. The variations are traceable to seasonal change and are not considered significant. Radiochemical quality has also been analyzed. Purtymun et al. (1980, 0208) and the Laboratory's annual environmental surveillance reports provide water quality data.

2.6.7 Fenton Hill Site

The Fenton Hill site is located about 40 mi west of Los Alamos on the western flank of the Valles Caldera (Figure 2-4). Investigations at this site are focused on the extraction of heat from dry geothermal reservoirs known as hot dry rock.

2.6.7.1 Water Supply

Water for drinking and industrial needs at the Fenton Hill site is furnished by Well FH-1, a perched aquifer at a depth of about 450 ft. An aquifer test conducted in 1980 determined that this aquifer is of limited extent (Becker et al. 1981, 0028). The water levels in FH-1 vary according to the amount of pumpage, which reflects the demand for drilling or testing at the site. The water level declined from 365 ft in 1976 to 382 ft in 1986. The decline in water level since 1976 indicates that the withdrawal of water has exceeded the amount of recharge to the aquifer. Overall, there have been no significant changes in the chemical quality of water (ESG 1989, 0308).

Environmental monitoring is performed in the vicinity of the site to assess any impacts from the geothermal operations. Water quality studies of surface and groundwaters, which include mineral and hot springs, wells, and streams, began before construction and testing of the hot dry rock reservoir. There have been no significant changes in the chemical quality of the water. The results of water sampling are published in the Laboratory's annual surveillance reports (e.g., ESG 1989, 0308) and in reports on water quality in the vicinity of Fenton Hill (e.g., Purtymun et al. 1988, 0212).

2.6.7.2 Experimental Geothermal Holes

Investigations at the Fenton Hill site are based on the concept of extracting heat from dry geothermal reservoirs by developing artificial hydrothermal systems. The site contains a system of two deep holes completed in dry but hot Precambrian granitic rock. The holes are connected by a series of large cracks created by hydraulic fracturing. Water circulated under pressure in the cracks recovers heat from the geothermal reservoir. Two separate systems, one at 9,000 ft and another at 15,000 ft, have been constructed and are being evaluated for potential energy development (Heiken 1985, 0131; Murphy et al. 1980, 0149).

2.6.8 Special Studies

2.6.8.1 Disposal Site Hydrology

2.6.8.1.1 Capping Studies

Research activities at the Laboratory have concentrated on evaluating the design and performance of different soil and rock materials used in trench cap and landfill covers (Appendix D). The studies have included both modeling and evaluating field performance. The design of trench caps and landfill covers for managing water movement and biota intrusion has been evaluated by Nyhan et al. (1990, 0173), Perkins and Cokal (1986, 0175), Hakonson et al. (1987, 0127), and Nyhan et al. (1989, 0172). The effectiveness of trench caps as biobarriers to both flora and fauna has been investigated by Hakonson et al. (1987, 0127), Nyhan (1989, 0154), Nyhan et al. (1986, 0170), Hakonson et al. (1983, 0125), and Hakonson and Gladney (1982, 0116). Nyhan et al. (1983, 0163) have evaluated the effectiveness of trench caps in preventing erosion. Trench cap effectiveness has also been evaluated through model simulation studies (Devaurs 1989, 0047). Most studies have concentrated on investigating those scenarios that permit penetration through the trench caps, causing exposure of the buried waste.

2.6.8.1.2 Studies of Moisture and Contaminant Migration

The movement of water and dissolved contaminants through the unsaturated zone has been investigated at Los Alamos in field studies using large-diameter caissons and different soil sequences and contaminant combinations. Lane (1983, 0137) and Polzer et al. (1986, 0181) have performed tracer studies, and Nyhan and Barnes (1989, 0156) have modeled storage of soil water in waste storage trenches.

2.6.8.2 Geochemistry

Since the late 1950s, the Laboratory has been investigating local geochemical conditions using cations, anions, and actinides. These investigations aimed at understanding the chemistry and resultant mobility of actinides, ions, and elements associated with wastes and included tracer simulation studies. Early investigations addressed soil adsorption of radioactive wastes (Christenson et al. 1958, 0224); more recent studies have concentrated on adsorption processes. The latter studies include batch studies (Polzer and Fuentes 1985, 0179; Fuentes et al. 1984, 0106), batch and column studies (Fowler et al. 1979, 0100), and modeling adsorption (Fuentes and Polzer 1987, 0105; Polzer et al. 1984, 0180). Leaching studies have examined ion exchange resins buried in Bandelier Tuff (Essington et al. 1986, 0496). The mobility of actinides has been examined (Polzer et al. 1984, 0180), as well as their association with colloids (Penrose et al. 1990, 0174; Polzer et al. 1983, 0370). One-dimensional, steady-state, unsaturated models have been used to determine chemical mobility (Fuentes and Polzer 1987, 0105; Fuentes and Springer 1987, 0429). Combined geochemical/geohydraulic modeling has also been used to investigate geochemical isolation (Gruber 1988, 0113).

2.6.8.3 Run-Off and Erosion

Limited simulation studies of run-off and erosion processes have been performed. They range from use of the universal soil loss equation to predict movement of plutonium from fallout sources (Foster and Hakonson 1987, 0428); to development of hydrologic and sediment transport models to follow contaminants in alluvial channels (Lane and Hakonson 1982, 0139); to mathematical models of run-off, sediment yield, and contaminant transport on the scale of watersheds in semiarid regions (Lane et al. 1985, 0140).

2.6.8.4 Geochemical Studies of Soils and Bandelier Tuff

Many of the contaminants present at Los Alamos, especially organic and actinide contaminants, do not occur naturally. The media most susceptible to contamination are soils (Nyhan et al. 1978, 0161) and the Bandelier Tuff (Griggs and Hem 1964, 0313), which are exposed over most of the area affected by Laboratory operations. The purpose of the geochemical studies (Appendix E), is to determine the range of background concentrations of important contaminants, such as barium, beryllium, chromium, lead, and uranium, in several soil series and sediments and in the Bandelier Tuff at the Laboratory. Evaluation of these elemental concentrations is required for establishing the extent of soil, sediment, and Bandelier Tuff contamination at the various operable units.

In order to develop a chemical background model for soils, it is necessary to assess the chemical variability among the soil series. Each soil consists of several soil horizons that show different physical properties and that are chemically distinct. The soils have the potential to be rather highly chemically variable because of the varying content of clay minerals, ferric oxyhydroxides, humic acids, silicate minerals, carbonate minerals, and glass. If there are variations within a soil series, a significant portion of the variation is present at each sample location.

The Bandelier Tuff is made up of an upper (Tschirege) and lower (Otowi) member. Each member consists of an airfall tuff at the base, followed by ash flows. The ash flows of the lower member have not been subdivided, but Crowe et al. (1978, 0041) recognize three cooling units within the ash flows of the upper member. More recently, Vaniman and Wohletz (1990, 0541) separated the upper member of the Bandelier Tuff into four cooling units. The uranium concentrations in the airfall of the lower member range from 14.0 to 17.8 ppm, averaging 16.9 ppm, although, omitting sample 18/12, values for the lower member, ash falls range from 4.9 to 17.6 ppm, averaging 10.0 ppm (Kuentz 1986, 0602). In the upper member, uranium concentrations range from 6.86 to 11.35 ppm in Cooling Unit 1 (excluding Sample 4250.1) and average 8.8 ppm. In Cooling Unit 2, the uranium concentrations range from 4.0 to 4.9 ppm, (Crowe et al. 1978, 0041). The data set for the ash flows of the lower member is the only one in which samples were obtained from several locations. The large range of uranium concentrations in this unit, however, is not caused solely by lateral compositional variations within the unit. A significant portion of the variation is present at each sample location.

2.6.8.5 Geohydrologic Modeling

Combined discharge and transport models have been developed and used in laboratory settings to predict the movement and redistribution of contaminants. One

model that predicts run-off, sediment yield, and contaminant transport on a watershed-sized scale in semiarid environments was used to predict plutonium transport (Lane et al. 1985, 0140).

Other models were developed to predict flow in porous media. The TRACR3D code (Travis and Birdsell 1991, 0523; Travis and Nuttall 1984, 0385), developed at Los Alamos, models transient and two-phase flow and multicomponent transport in porous media. This model has been applied to field and laboratory simulations (Perkins et al. 1985, 0176). In addition, TRACR3D has been used to model radiocolloid transport (Travis and Nuttall 1984, 0385). CREAMS has been used to model vertical transport of radionuclides (Devaurs and Springer 1988, 0050). Unsaturated flow and contaminant transport (a different, unnamed code) have been modeled at a former waste disposal area (HydroGeoLogic 1989, 0133).

2.6.8.6 Flood Plains

The HSWA Module requires that all 100-yr flood plains for major watersheds within the Laboratory complex be defined. Because maps of 100-yr flood plains do not exist, they must be generated for the entire facility. The computational methodology used to define these flood plains conforms to all requirements specified in 40 CFR 270.14(b)(11)(iii) (EPA 1990, 0432). The computer models HEC-1 (Flood Hydrograph Package) and HEC-2 (Surface Water Profiles) prepared by the Army Corps of Engineers and Dodson & Associates (1990, 0235; 1982, 0236) will be used to complete this task. These models are recognized as standard industrial and regulatory compliance tools for ungaged watersheds.

The HEC-1 computer code simulates the rainfall run-off process in a given watershed and produces a stream discharge hydrograph in response to a single-storm hydrograph. The HEC-2 model uses the peak discharge from this hydrograph, along with known flood plain geometry, to hydraulically compute water surface profiles. These computed profiles at numerous cross sections along a stream channel define the 100-yr flood plain. All input data requirements for both models are currently available or may be computed from known hydrologic relationships. The HEC-2 model input data consist of digitized topographic information for stream channels, which have been automatically extracted from the Laboratory's AUTOGIS MOSS mapping system using software developed specifically for this task. Once the HEC-2 simulations have been completed, definitions of the 100-yr flood plain for each major watershed will be automatically entered back in the MOSS system. This procedure will ensure that the Laboratory can meet the HSWA Module requirements for 100-yr flood plain maps for the entire facility. All flood plain definitions will be specified in standard New Mexico plane map coordinates.

A map at a scale of 1:2000 showing all 100-yr flood plains is presented in Appendix C; however, upon request, scale maps at 1:400, or smaller, can also be made available from the MOSS system. These flood plain definitions will be archived in the MOSS mapping system for future reference. In addition, a comprehensive report will document HEC-1 and HEC-2 model input data for each watershed. Explanations of data used in these simulations will be documented, and all assumptions will be justified by citing the professional literature. The Environmental Protection Group (EM-8) will maintain model input data files on computer disks for future reference and will make this information available to the DOE, EPA, NMED, or the Army Corps of Engineers upon request.

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3.0 DESCRIPTION OF THE ENVIRONMENTAL RESTORATION PROGRAM

This chapter of the Installation Work Plan (IWP) describes the Environmental Restoration (ER) Program that the Department of Energy (DOE)/University of California (UC) are implementing for Los Alamos National Laboratory (the Laboratory). The processes presented in the following sections are designed to meet the following goals of the ER Program at the Laboratory:

- to ensure that the environmental impacts associated with past and present activities at the Laboratory are thoroughly investigated and that appropriate corrective action is taken to protect human health and the environment;

- to comply with the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response and Liability Act (CERCLA), the National Environmental Policy Act (NEPA), the Atomic Energy Act (AEA), their implementing regulations, DOE orders, and other applicable rules by establishing procedures and schedules for efficiently developing and implementing corrective actions at the Laboratory and monitoring the results of those actions; and

- to provide both formal and informal mechanisms through which all interested parties, [e.g., DOE, Environmental Protection Agency (EPA) Region VI, New Mexico Environment Department (NMED), and the public] can participate in the corrective action review process at the Laboratory.

The Hazardous and Solid Waste Amendments (HSWA) Module provides the principal framework for implementing the ER Program at the Laboratory. However, sites to be investigated and evaluated include not only the solid waste management units (SWMUs) described in the HSWA Module but sites that contain radioactive materials and other substances not addressed by RCRA. The latter sites are called areas of concern (AOCs). In this document, SWMUs and AOCs are collectively referred to as potential release sites (PRSs).

3.1 The Department of Energy's Environmental Restoration Program

In 1984, DOE's Albuquerque Operations Office (DOE/AL) (now called the Albuquerque Field Office) created an environmental cleanup program entitled the Comprehensive Environmental Assessment and Response Program (CEARP) (DOE 1987 0264) to fulfill DOE's obligations under several statutes and regulations, including

- CERCLA, as amended by the Superfund Amendments and Reauthorization Act;

- RCRA (40 CFR 260-270 and 40 CFR 300), as amended by HSWA in 1984;

- NEPA (40 CFR 1500-1508); and

- the AEA of 1954 (10 CFR 200-1060).

DOE/AL began to implement CEARP at the Laboratory in 1984. CEARP provided guidance for implementing and conducting assessment and remediation activities from 1984 until March 1987, when DOE Headquarters (DOE/HQ) created a national ER Program for all DOE Defense Program facilities at the request of the House Armed Services Committee. This request arose from congressional concern over a 1987 General Accounting Office report that indicated that DOE could not account for funds used to conduct cleanup activities. In addition, public concern over environmental problems at DOE facilities was increasing throughout the country.

Responsibility for the ER Program is currently located in the Office of Environmental Restoration and Waste Management at DOE/HQ (DOE 1991, 0549). The authority to implement the ER Program is derived from the following DOE orders:

- Radioactive Waste Management [DOE Order 5820.2A (DOE 1988, 0074];
- Hazardous and Mixed Waste Management [DOE Order 5400.3 (DOE 1989, 0526);
- Comprehensive Environmental Response, Compensation, and Liability Act Requirements [DOE Order 5400.4 (DOE 1989, 0078)];
- Environmental Compliance Issue Coordination [DOE Order 5400.2A (DOE 1989, 0077);
- Environment, Safety and Health Program for Department of Energy Operations [DOE Order 5480.1B (DOE 1990, 0730)];
- Environmental Protection, Safety, and Health Protection Standards [DOE Order 5480.4 (DOE 1984, 0059]; and
- National Environmental Policy Act Compliance Program [DOE Order 5440.1D (DOE 1991, 0815) and AL Order 5440.1B (DOE/AL 1982, 0430)].

The primary purposes of DOE's ER Program are to

- implement RCRA Sections 3004(u) and (v), RCRA facility assessment (RFA), RCRA facility investigation (RFI), RCRA corrective measures study (CMS), and RCRA corrective measures for existing SWMUs;
- implement CERCLA preliminary assessment/site investigation, remedial investigation, feasibility study, remedial design, and remedial action, as appropriate;
- carry out corrective actions at RCRA-regulated land units in operation before March 1987, including those at which underground storage tanks are located;
- decontaminate and decommission surplus facilities;
- develop and demonstrate the technologies necessary to clean up;

- manage expenses associated with cooperative multiparty cleanup plans and activities;
- protect natural resources and restore those damaged by contamination from past release of hazardous substances;
- install long-term environmental monitoring systems; and
- conduct any CERCLA assessments necessary before real property is considered for disposition.

Significant items explicitly excluded from DOE's ER Program include

- RCRA compliance for active waste streams;
- emergency response to spills and releases and reporting of releases under CERCLA 103(a) and (b);
- new waste management facilities, except as an integral part of remedial actions; and
- routine monitoring of the postclosure environment and maintenance of postclosure monitoring systems.

To implement the ER Program, DOE/HQ require that a five-year plan be prepared for all facilities. That plan is designed to consolidate the plans for all DOE installations into a single plan to coordinate all DOE ER activities and is reviewed and revised annually. The five-year plans for FYs 91-93 have been prepared and released to the public. The plan prioritizes ER activities and is used by DOE for scheduling and budgeting purposes.

The Laboratory's Decontamination and Decommissioning (D&D) Program is integrated with the ER Program. The two programs were integrated because PRSs and D&D projects at the Laboratory are often collocated; thus, operations of these programs often affect the operations of the other, and integrating the two programs is intended to make cleanup more efficient.

Under the integrated approach, the Environmental Restoration Group (EM-13) retains oversight of all remediation mandated by RCRA and CERCLA. However, when this remediation is associated with D&D projects, OUPLs delegate to the Waste Management Group (EM-7) cleanup responsibilities that are ordinarily directed by EM-13, and EM-13 transfers the funding necessary to accomplish this work. Annex I provides additional discussion of these arrangements.

3.2 The Environmental Restoration Program at Los Alamos National Laboratory

In the 1970s, DOE/UC began a formal program to identify contamination problems resulting from early defense activities, and, in 1983, they began a formal program to characterize these contaminated sites. As a result, the Laboratory remediated several sites, implemented institutional controls, and collected the information that serves as a starting point for current investigations.

Between 1984 and 1987, the Laboratory was evaluated under CEARP. A major objective of this program was to determine whether past waste disposal practices—practices in effect before recognition of environmental hazards and passage of extensive environmental legislation—created environmental problems that require remedial action today.

During Phase I of CEARP, DOE/UC conducted and documented PA/SI activities specified by CERCLA in the first comprehensive attempt to identify potentially hazardous waste sites at the Laboratory. The results are summarized in the CEARP Phase I report (DOE 1987, 0264). DOE submitted this document to EPA's Region VI in October of 1987 to fulfill the CERCLA 103(c) notification requirement. The CEARP Phase I report was also distributed to the state and to the public.

After establishing the ER Program at DOE/HQ, DOE/UC established the ER Program Office in the Laboratory's Environmental Management (EM) Division to implement the program at the Laboratory. Although the ER and CEARP programs differ somewhat in scope, the intent is to fulfill DOE/UC's obligations under both CERCLA and RCRA. The ER Program retains the need for agency approval and oversight and for public review and comment during site characterization activities (RFI), selection of the appropriate remedial alternative (CMS), and implementation of the selected remedial action. SWMUs identified by EPA for corrective action have been included in the Laboratory's ER Program.

The DOE/UC ER Program at the Laboratory has been modified to address the requirements of the HSWA Module, which became effective May 23, 1990, and to incorporate site-specific needs, as well as DOE's requirements for organizing, managing, reporting, funding, and tracking the program.

3.3 Structure of the Environmental Restoration Program at Los Alamos National Laboratory

The plan for managing DOE/UC's ER Program is presented in Annex I of this IWP. The HSWA Module requires inclusion in the program of four additional planning and implementing elements, which are discussed in Annexes II through IV: an overview of the ER Program's Quality Program Plan, the Health and Safety Program Plan, the Records Management Program Plan, and the Community Relations Program Plan.

The Laboratory is organized by divisions, program directors, and offices that report through associate directors to the director of the Laboratory (Figure 3-1). The EM Division reports to the Associate Director for Operations for all line management activities. All programmatic activities are managed through the Applied Environmental Technologies Program Director's office, which reports to the Associate Director for Energy and Environment. The ER Program Office (EM-13) tracks and manages the ER Program. The group leader of EM-13 serves both as the line manager for the group reporting to the EM division leader and as the program manager for the ER Program reporting to the Applied Environmental Technologies Program director. The program manager is responsible for the effective implementation of the ER Program throughout the Laboratory.

The deputy group leader of the Environmental Restoration Group (EM-13) reports to the program manager and functions as the deputy program manager for the ER Program in the program manager's absence. Other responsibilities include assisting the program manager in managing the program, interfacing with the Laboratory's

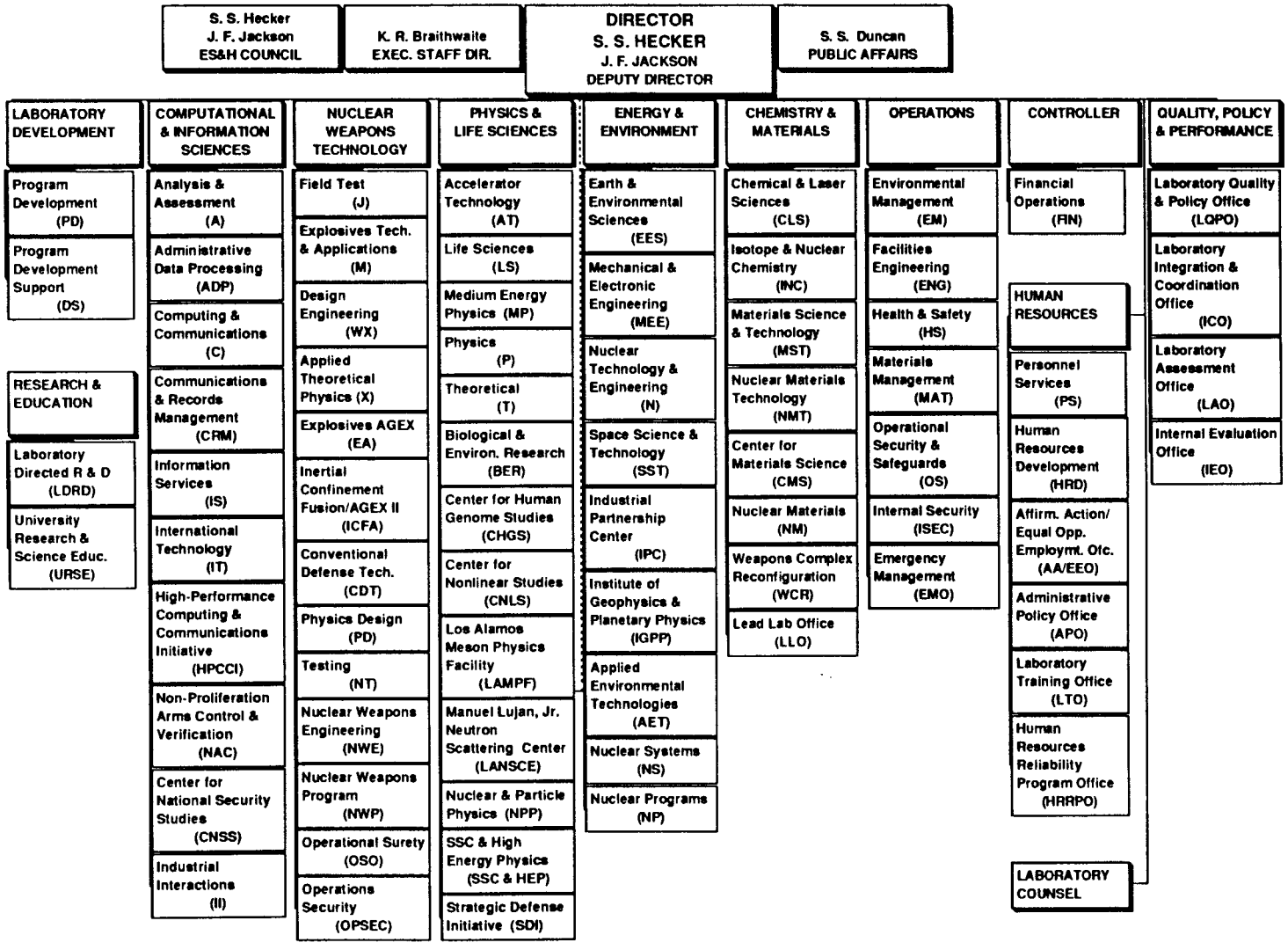

Figure 3-1. Organization of Los Alamos National Laboratory.

upper management, interfacing with DOE and regulatory personnel, and interacting with the public. In addition, the deputy group leader oversees programmatic support in information management, records processing, risk assessment and decision analysis, health and safety, community relations, and document preparation services.

The senior programmatic project leader (SPPL) reports to the ER Program manager, supervises ER programmatic project leaders and the Planning, Scheduling, Cost-Estimating, and Reporting Team, and provides technical and programmatic guidance for the participants in the ER Program at the direction of the program manager. The SPPL has direct responsibility for developing the annual technical and cost/schedule baseline, the Five-Year Plan, and monthly cost/schedule progress reports.

Programmatic project leaders (PPLs) are the principal points of contact between the operable unit project leaders (OUPLs) and technical team leaders (TTLs) and the ER Program Office. Working with the ER Program Office, PPLs provide technical and administrative guidance to the OUPLs and TTLs. The PPL assists OUPLs and TTLs in obtaining appropriate and sufficient resources to perform their assigned duties; reviews the progress of OUPLs and TTLs; performs technical and policy reviews of documents prepared for the ER Program by OUPLs, TTLs, and affiliated staff; and reviews and recommends management action as appropriate for scopes of work, proposals, and requests for work to be supported by the ER Program.

OUPLs, who report to the program manager through PPLs and the SPPL, are responsible for ensuring that the work they perform for the ER Program meets all regulatory requirements. OUPLs are responsible for managing the corrective action process for their respective operable units. The project leaders for quality, health and safety, records management, the Facility for Information Management, Analysis, and Display (FIMAD), and community relations are responsible for managing their areas to support the OUPLs. The responsibilities of project leaders are presented in detail in the Environmental Restoration Group's (EM-13's) Administrative and Quality Procedures for Environmental Restoration.

The ER Program is a large, interdisciplinary program that will continue for several decades. To assist the OUPLs, the Laboratory is creating technical teams from various groups and divisions of the Laboratory (Figure 3-2). External support (from various contractors, universities and DOE facilities) may be included. The technical teams provide the ER Program Office with technical resources for implementing the program. Team members interact with all OUPLs to provide them with the expertise (e.g., geochemistry) needed to meet program goals. For each team, the ER Program Office has appointed a PPL, who is responsible for establishing and overseeing the team. The PPL interacts with the TTLs to assign personnel to projects, to schedule effort, and to resolve conflicts among programs. Outside contractors are used for program activities when limitations in Laboratory resources threaten the Laboratory's ability to meet the requirements of the HSWA Module or when outside contractors can perform the required work more economically or otherwise more advantageously than would be possible if the work were performed by the Laboratory.

The composition and function of each technical team are described in the following subsections.

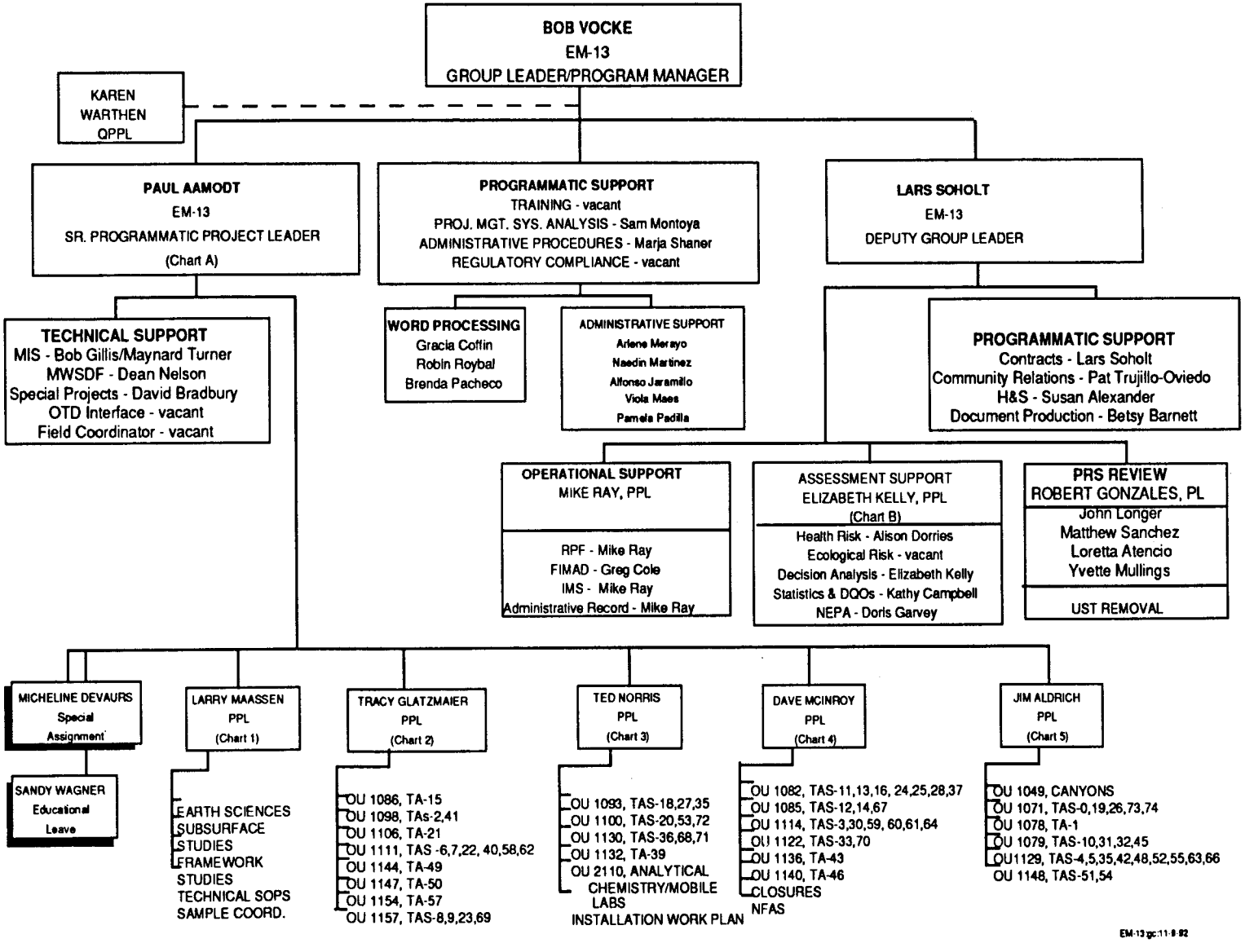

Figure 3-2. Organization of the Environmental Restoration Program at Los Alamos National Laboratory.

3.3.1 Community Relations Team

The ER Community Relations Team integrates the community relations needs of the ER Program with existing community relations and public affairs programs and policies at the Laboratory in an efficient and cost-effective manner (Annex V). The primary function of the Community Relations Team is to keep the public informed of ER activities and to receive and respond to public input on those activities, which it does by means of the Community Relations Program Plan (Annex V). The plan includes provisions for (1) providing the community with information about ER Program activities in a timely manner, (2) establishing two-way communication between interested parties and the Laboratory, (3) being proactive in providing information to the public and in soliciting participation, (4) affording opportunities for public input on ER Program activities, and (5) providing for effective management of public involvement.

3.3.2 Decision Support Team

The Decision Support Team provides assistance to both ER Program management and individual OUPLs in the areas of decision analysis, cost/benefit analysis, and related methodologies, which can be used to streamline RCRA investigations and decision-making processes. Decision analysis helps program management and OUPLs to identify and evaluate remediation alternatives, to adapt programmatically defined evaluation criteria to specific OUs and PRSs, and to integrate cost and resource constraints when evaluating investigation and remediation alternatives. The results of these tasks provide guidance for activities such as archiving, defining data needs, developing data quality objectives for those data needs, and integrating environmental data with other information to select appropriate corrective measures.

3.3.3 Document Preparation Team

The Document Preparation Team is composed of members of the Writing and Editing Group (IS-11), supported as necessary by the Systems Technology Support Group (IS-5), the Photography and Printing Group (IS-9), and the Illustration, Design, and Video Group (IS-12). The goal of this team is to produce readable and technically sound documents for the ER Program. The Classification Office (OS-6) reviews all documents to ensure that no classified information is released.

3.3.4 Earth Sciences Team

The Earth Sciences Team is headed by a TTL who is supported by principal investigators for geology, geophysics, hydrology, and geochemistry. The TTL is responsible for providing personnel resources to OUPLs for the RFI/CMS process and for the development of a geologic, hydrologic, and geochemical baseline for the Pajarito Plateau area (framework studies), which is required by the HSWA Module. This information is used to guide certain site characterization activities and is especially useful for evaluating data necessary for risk assessment as sites are being assessed for radiological or hazardous constituents above natural levels.

3.3.5 Environmental Assessment Team

This technical team, which is composed of members from the Environmental Protection Group (EM-8), ensures that ER Program activities comply with regulatory requirements, including NEPA. The NEPA assessments include, at a minimum, an evaluation of the short- and long-term beneficial and adverse effects of the remedial actions selected, any adverse effects on environmentally sensitive areas, and an analysis of measures to mitigate adverse impacts.

3.3.6 Facility for Information Management, Analysis, and Display Team

The FIMAD Team has been established to support the electronic information needs of the ER Program. The principal task of the FIMAD is to provide all program participants and the general public with access to all data related to ER Program activities. A network of UNIX work stations and X terminals at various sites throughout the Laboratory and townsite provides access to the ER Program's data base. Data-processing activities currently supported on the network include geographical analysis and technical data management and analysis. Future support and tools that will be provided through the FIMAD include document management, video and image management, visualization through two- and three-dimensional graphics, data compression and conversion, geostatistics, data integration, and possibly project and program management.

The FIMAD team has the responsibility for acquiring and maintaining the programwide electronic data base and for generating maps. The FIMAD is being developed as an open, upgradable system, and current efforts are directed toward developing a user-friendly interface to data and data analysis tools.

3.3.7 Health and Ecological Risk Assessment Teams

The Health and Ecological Risk Assessment teams are composed of staff from EM, Earth and Environmental Sciences, and Analysis divisions. The Laboratory recognizes the need for risk assessment teams that consist of representatives of all pertinent disciplines. The heart of any comparison of alternative corrective measures, including the no-action alternative, is a risk assessment. Risk assessment is also necessary to establish the baseline risks to be addressed at each site. A well-done risk assessment could preclude the costs of studying and implementing alternatives based on overly cautious estimates. The risk assessment teams are interdisciplinary teams whose functions are to define pathways of exposure for the public, to define ecologically sensitive areas, to develop risk criteria to be used in the decision-making process, and to make preliminary risk assessments based on available data so that priorities for cleanup can be set.

3.3.8 Mixed-Waste Storage and Disposal Facility Team

The goals of the Mixed-Waste Storage and Disposal Facility (MWSDF) Team are to select a suitable site, develop facility and operating criteria, and design and construct a proposed new MWSDF at Los Alamos. Associated tasks include preparing appropriate documentation in accordance with NEPA and site suitability studies, obtaining required state (NMED) and federal (EPA) permits, and ensuring compli-

ance with all required quality assurance (QA) and health and safety (H&S) requirements. When constructed, the MWSDF will be used primarily for waste generated by the Laboratory's ER Program activities. The need for treatment facilities to accommodate the ER Program is yet to be fully addressed, but existing waste treatment facilities will be used to the extent they are available.

3.3.9 Planning, Scheduling, Cost-Estimating, and Reporting Team

The Planning, Scheduling, Cost-Estimating, and Reporting Team consists of members of the ER Program Office (EM-13), the Technical Engineering Support Group (MEE-4), and contracted support. The goal of the team is to provide the ER Program with the planning, scheduling, cost-estimating, and reporting needed to ensure effective implementation of the ER Program. The ER Program Office has prepared a comprehensive listing of the Laboratory's PRSs, which is being used for FY94 Five-Year Plan resource planning and scheduling purposes.

This team develops detailed cost estimates for all program activities. The cost estimators work closely with ER Program project leaders to identify the activities and elements that require cost estimates and to ensure that such estimates are developed, when needed. The planning and tracking functions are described in Annex I.

3.3.10 Records Management Team

The Records Management Team supports ER Program participants in handling significant volumes of record packages, including technical data generated by the ER Program. Implementation of the Records Management Program Plan (Annex IV) accommodates the ongoing need for coordinated protection of ER Program records. Activities conducted under the Records Management Program Plan ensure that ER Program records are handled in a manner demonstrably consistent with regulatory guidelines and include integration of quality program guidelines, standardized documentation controls, and development of the administrative record required under CERCLA.

3.3.11 Sample Coordination Facility Team

It is projected that several hundred thousand samples will be collected for chemical analysis to support the ER Program. The coordination between the proposed sampling activities and the requested analytical support for each sampling project is critical to the success of these programs.

3.3.12 Statistics and Data Quality Objectives Team

The Statistics and Data Quality Objectives Team provides support to the OUPLs, as well as to programmatic data collection and analysis activities such as framework studies. Specific areas of support include

- development of data quality objectives, that is, requirements for sampling and analysis plans that must collect information for well-specified purposes, including making decisions about

the need for or effectiveness of corrective measures, or providing background information in a form suitable for extrapolation to all sites;

- statistical design of sampling and analysis plans to meet specified data quality objectives;

- statistical data analysis for all phases of data evaluation: evaluation of preliminary field screening information for the purposes of making final sampling decisions, data quality assessment, and statistical hypothesis-testing to support a decision.

3.3.13 Subsurface Studies Team

The Subsurface Studies Team is responsible for all drilling, borehole geophysical logging, and sample management activities in support of RFI and CMS investigations. A drilling package written for each OU is site-specific and responds to the sampling needs of individual OUs. The drilling package consists of a detailed drilling plan and drilling specifications, a borehole geophysical logging plan, and a sample management plan. The team is responsible for preparing and overseeing all drilling and borehole geophysical logging contracts. The team is designing and will operate a permanent sample management facility and mobile support facilities. In addition, the team performs pilot studies to validate new drilling technologies.

3.4 Approach to Remediation

3.4.1 Grouping of Potential Release Sites

PRSs exist throughout the Laboratory, and several exist off Laboratory land. Under the ER Program, the sites have been aggregated into OUs so that site characterization and potential remediation can be addressed in an efficient, cost-effective manner, as required by the HSWA Module. These OUs are logical groupings of PRSs. Such groupings may include geographical aggregations that have similar physical features, contaminant sources or types, schedules, or likely response actions. The geographical boundaries of OUs and Laboratory technical areas (TAs) do not necessarily coincide. Some OUs may encompass more than one TA (e.g., OU 1071 includes TAs -0, -19, -26, -73, and -74). Because DOE's management structure relies on OUs for funding and tracking purposes, the ER Program Office needs to meet the requirements of the HSWA Module through the use of OUs.

3.4.2 Schedule for Completing RFI Work Plans

Each OU has a separate work plan. The schedule shown in Table 3-1 is derived from Tables A and B in the HSWA Module, and the schedules in each work plan are incorporated in the permit and become enforceable upon EPA approval.

Table B is a subset of Table A and includes all SWMUs that EPA considers to have high priority. Currently, Table A contains 603 SWMUs and Table B contains 182, but this number will change as EPA modifies the HSWA Module during the RFI/CMS process.

TABLE 3-1

SCHEDULE FOR WORK PLAN COMPLETION

SWMU Due Date	HSWA Module Table A SWMUs (%)	HSWA Module Table B SWMUs (%)
5/23/91	10	20
5/23/92	35	55
5/23/93	55	100
5/23/94	100	100

In compliance with HSWA Module Section H.(3)(a), DOE/UC have prepared nine work plans—the first was delivered to EPA in May 1991, the remaining eight in May 1992—to meet the requirement to address 35% of the SWMUs in Table A and 55% of the SWMUs in Table B by May 23, 1992. This work is continuing to meet the RFI work plan requirements for additional SWMUs, as defined in Section H.(3)(b) of the HSWA Module.

3.4.3 Potential Release Site Data Base

In early 1987, EPA Region VI performed an RFA to identify all potential SWMUs at the Laboratory. The RFA was completed in August 1987 but was not formally released. Upon receipt of the RFA, DOE/UC prepared a SWMU report (International Technology Corporation 1988, 0329) in an attempt to incorporate additional information in the RFA SWMU list and to correct inaccuracies in the RFA. This report was released in December 1988, and it combined lists from the CEARP Phase I report (DOE 1987, 0264), the RFA, and internal records searches and interviews. The report identified approximately 1,100 PRSs. The EPA selected the 603 SWMUs identified in the HSWA Module from this report, based on the agency's preliminary assessment of the potential impact to human health and safety.

In 1989, the Laboratory further revised and verified existing information, which was compiled in a data base (Appendix G, LANL 1990, 0145) completed in November 1990. This undertaking involved site visits and discussions with operating groups. No sites were eliminated, but many were combined, some were added, and AOCs were included. The field information was coupled with an extensive search of maps and archives. Each PRS is coded with a unique identification number that ties it to a particular TA.

The primary function of the PRS data base is to provide a baseline of PRSs from which the RFI for each OU will be developed. In most cases, the scope of the RFI will be to confirm or deny the presence of a release and to determine the nature and extent of contamination. In some cases, sufficient historical information may be available to justify a recommendation of no further action. These options are discussed further in Chapter 4.

3.4.4 Notification of New Units

As new PRSs are identified during the RFI process, environmental surveillance, audits, or other activities, DOE notifies EPA of a proposed new PRS within 15 days of its concurrence with identification of the new PRS. This notification includes a PRS summary data sheet containing all information available at that time [e.g., location, type of unit, dimensions, waste types (known and suspected), and period of operation]. In addition to this technical information, DOE submits to EPA a plan for future action. If required by EPA, an action plan will be prepared, which may include, as appropriate,

- completing the PRS summary data sheet, using historical and operational information from records searches and interviews with long-term employees;
- assigning the new PRS to an existing OU for which an RFI is to be conducted; and
- addressing proposed interim remedial measures.

This procedure is outlined in Administrative Procedure (AP) LANL-ER-AP-04.1, "Identification and Reporting of Solid Waste Management Units and Identification of Other Areas of Concern for the Environmental Restoration Program," in accordance with Section F of the HSWA Module. After reviewing the action plan, EPA either approves it or instructs DOE/UC to prepare a formal SWMU assessment plan.

Because DOE/UC have been identifying and investigating SWMUs for the past few years, it seems unlikely that SWMUs posing a significant environmental threat have yet to be discovered. In the unlikely event that a potentially significant threat to human health or the environment is discovered, DOE/UC will prepare a formal SWMU assessment plan. Upon receipt of information on the newly identified SWMU, EPA will notify DOE/UC of its selection of the proposed action as discussed in the SWMU assessment plan. EPA may, at that time, request a SWMU assessment plan. DOE/UC would prepare this plan to be consistent with Section F.2-6 of the HSWA Module. The assessment plan will contain a sampling and analysis plan adequate to determine the nature and extent of contamination. EPA will either approve the proposed assessment plan, provide comments for revision, or revise the plan. DOE/UC will implement the plan within 15 days of receipt of a written notice of approval.

Within 60 days of completion of the SWMU assessment, DOE/UC will submit a SWMU assessment report. The report will present the findings of the investigation and will include, as appropriate for each unit,

- location,
- type and function,
- description of the structure(s),
- period of operation,

- type and volume of wastes managed, and
- results of sampling and analysis.

EPA will review the assessment report and will determine the need for additional investigation or corrective measures. DOE/UC may be required to prepare an additional plan for these activities, which will be incorporated in an RFI work plan for EPA review and approval.

Discovery of new releases of hazardous materials from existing SWMUs or sites previously identified as needing no further action will be reported to EPA within 24 hours of discovery. DOE/UC will follow oral notice with a written notification that presents existing information related to the location, nature, and type of release and proposed corrective measures. For the purposes of the DOE/UC ER Program, a release is considered to exist when hazardous wastes are found adjacent to a SWMU in concentrations exceeding the action levels in proposed Subpart S of 40 CFR 264 (EPA 1990, 0432) as criteria for determining that no further corrective action is required at a SWMU after an RFI. These levels are discussed further in Section 3.5. DOE/UC propose that most newly discovered releases at existing SWMUs be incorporated in the RFI work plan for the OU in which the SWMU is located. For those few instances when it is impractical to incorporate the PRS in an RFI (e.g., when the RFI is almost complete), an assessment plan will be prepared if EPA so requests.

This process is described in detail in LANL-ER-AP-04.2, "Reporting of Newly Identified Releases from Solid Waste Management Units" (June 25, 1991) to meet the requirements of Section G of the HSWA Module.

3.4.5 Summary Data Sheets for Potential Release Sites

The summary data sheets for PRSs are contained in the Potential Release Site Data Base, which is maintained at the FIMAD. These sheets summarize the status of currently known PRSs and provide a brief description of each SWMU and of the potential environmental problems to be addressed by the ER Program. A detailed discussion of PRSs is provided in the SWMU report (LANL 1990, 0145), which was submitted with the original IWP (LANL 1990, 0144).

In October 1992, the OUPLs were asked to examine available information about PRSs according to regulatory definitions of SWMUs. The result of this examination is a new list of PRSs, which has been incorporated in a request to EPA for a permit modification. The PRSs identified in Appendix F do not reflect the results of this latest change in the PRS list. It is expected that the list in the next revision of this IWP will show the PRSs that EPA deems to be SWMUs.

3.5 Requirements of the Corrective Action Process

3.5.1 Requirements for the RFI

To comply with applicable regulations and to keep all interested parties informed of progress made during the corrective action process, the ER Program prepares several types of plans and reports. The schedule for preparing the RFI, CMS, and

CMI plans and reports varies from OU to OU and is provided in individual RFI work plans. The schedule for preparing reports is given in Table I-7 of Annex I.

3.5.1.1 RFI Work Plan

The ER Program is preparing work plans for conducting RFIs. The generic requirements for preparing RFI work plans can be found in proposed Subpart S regulations (EPA 1990, 0432). The specific requirements are described in detail in the HSWA Module (Table 1-1), and EPA has provided specific guidance in Volume I of the interim final RFI guidance (EPA 1989, 0088). This IWP provides the framework for the preparation of individual work plans for the 24 OUs. Information of general nature is contained in this IWP so that RFI work plans need not repeat generic material.

Each RFI work plan must include a description of the overall approach, technical and analytical approaches and methods, QA procedures, and data management procedures. The HSWA Module also specifically requires the concurrent development of five plans as part of the RFI work plan: the Program Management Plan, Quality Project Plan, Records Management Project Plan, the Health and Safety Project Plan, and the Community Relations Project Plan. However, the HSWA Module allows the Laboratory to deviate from the specific guidance if the RFI work plan still covers the essential elements discussed above.

It is the policy of the ER Program Office to adhere to Section 2, Volume I, of EPA's RFI guidance document to the extent practicable (EPA 1989, 0088). To facilitate compliance with this detailed guidance while complying with the HSWA Module's requirements, the ER Program has developed a standard outline (Table 3-2) for RFI work plans. The outline is intended to provide flexibility in work plan preparation while incorporating the information required by the HSWA Module. The outline may be modified to accommodate the variations in OUs, but each plan must comply with RFI guidance, permit requirements, and regulatory requirements. DOE/UC RFIs will also comply with the substantive requirements of CERCLA. The outline is designed to guide the development of the RFI toward a logical and reasonably minimized sampling program by moving from the analysis of existing data to identifying data gaps in the conceptual model and finally to proposing a sampling plan to fill those gaps. One of the first responsibilities of the OUPL during the development of the work plan is to identify logical aggregations of PRSs in a manner that facilitates the RFI in accordance with the definition in proposed Subpart S.

3.5.1.2 Phase Reports and RFI Reports

Within 60 days of the completion of the RFI, the Laboratory is required to submit an RFI report and a summary report. The 60-day period begins at the time DOE determines that the RFI has been completed (i.e., approval of RFI report). The Laboratory proposes to include an executive summary as a stand-alone section of the RFI report to fulfill the obligation to submit a summary report. The executive summary will also be submitted to interested parties on the ER Program mailing list.

During the course of the RFI, the data collected sometimes indicate that the sampling plans presented in the RFI work plans should be modified. Phase reports are prepared to document the results of the initial sampling plans and the reasons for subsequent modifications. The requirements for the content of phase reports and

TABLE 3-2

OUTLINE OF WORK PLANS FOR RESOURCE CONSERVATION AND RECOVERY ACT FIELD INVESTIGATIONS

EXECUTIVE SUMMARY

1.0 INTRODUCTION

- 1.1 Statutory and Regulatory Background
- 1.2 Installation Work Plan
- 1.3 Description of OU ____
- 1.4 Organization of This Work Plan

2.0 BACKGROUND INFORMATION FOR OPERABLE UNIT

- 2.1 Description
- 2.2 History
- 2.3 Waste Management Practices

3.0 ENVIRONMENTAL SETTING

- 3.1 Physical Description
- 3.2 Climate
- 3.3 Biological and Cultural Resources
- 3.4 Geology
- 3.5 Conceptual Hydrologic Model
- 3.6 Conceptual Three-Dimensional Geologic/Hydrologic Model of OU____

4.0 TECHNICAL APPROACH

- 4.1 Aggregation of Potential Release Sites
- 4.2 Approaches to Site Characterization
- 4.3 Conceptual Exposure Models
- 4.4 Potential Response Actions and Evaluation Criteria
- 4.5 Sampling Strategies and Sampling Methods
- 4.6 Field Surveys

5.0 EVALUATION OF POTENTIAL RELEASE SITES

- 5.1 First PRS or PRS Aggregate
  - 5.1.1 Background
    - 5.1.1.1 Description and History
    - 5.1.1.2 Conceptual Exposure Model
      - 5.1.1.2.1 Nature and Extent of Contamination
      - 5.1.1.2.2 Potential Pathways and Exposure Routes
      - 5.1.1.2.3 Potential Public Health and Environmental Impacts
  - 5.1.2 Remediation Decisions and Investigation Objectives
  - 5.1.3 Data Needs and Data Quality Objectives
    - 5.1.3.1 Data Needs for Evaluating Health and Safety Risks
      - 5.1.3.1.1 Source Characterization
      - 5.1.3.1.2 Environmental Setting
      - 5.1.3.1.3 Potential Receptors
    - 5.1.3.2 Data Needs for Evaluating Other Impacts
  - 5.1.4 Sampling and Analysis Plans

TABLE 3-2 (continued)

OUTLINE OF WORK PLANS FOR RESOURCE CONSERVATION AND RECOVERY ACT FIELD INVESTIGATIONS

5.2 Second PRS or PRS Aggregate, etc.

6.0 UNITS PROPOSED FOR NO FURTHER ACTION

6.1 First Unit Proposed for No Further Action

6.1.1 Description and History
6.1.2 Rationale for Recommendation of No Further Action

6.2 Second Unit Proposed for No Further Action, etc.

ANNEX I Project Management Plan

ANNEX II Quality Assurance Project Plan

ANNEX III Health and Safety Project Plan

ANNEX IV Records Management Project Plan

ANNEX V Community Relations Project Plan

APPENDIX A List of Preparers

Other appendices, as appropriate.

RFI reports are given in the HSWA Module, Section P, Task V—Reports. The purpose of the reports is to "describe the procedures, methods, and results of all investigations of SWMUs and their releases, including information on the type and extent of contamination at the facility, sources and migration pathways, and actual or potential receptors." A Phase I report is normally prepared to describe proposed modifications to the RFI work plan to perform Phase II investigations. A Phase II report presents the results of all investigations performed under the approved RFI work plan in Phase I and provides adequate information to support further corrective action decisions at the site. If all PRSs in the OU are proposed for no further action, the Phase I report can serve as the final RFI report.

Each phase or final RFI report is accompanied by a summary report that provides the same technical information in a briefer format. These reports stand alone so that the reader does not have to consult other documents, such as the RFI work plans, for details of the investigation. However, some information, such as site and program descriptions, is presented in summary form, and the reader is referred to the IWP for more details. The ER Program proposes to use the outline in Table 3-3 for the Phase I and Phase II (or final RFI) reports. The same outline can be used for both reports, with the exception that the Phase II or final RFI report does not contain the sections pertaining to proposals for additional investigations before a CMS.) In some instances, the RFI may be done in more than two phases, resulting in reports for Phase I, Phase II, etc., and final RFI report.

TABLE 3-3

DRAFT OUTLINE FOR PHASE REPORT AND RFI REPORT

EXECUTIVE SUMMARY

1.0 INTRODUCTION

- 1.1 ER Program Basis and Description
- 1.2 Technical Approach to Site Characterization
  - 1.2.1 Decision Strategies
  - 1.2.2 Screening Action Levels and Risk Assessment Methodologies
  - 1.2.3 Potential Response Actions and Evaluation Criteria
  - 1.2.4 Methods for Establishing Data Quality Objectives
- 1.3 Overview of RFI Results
  - 1.3.1 Potential Release Sites (SWMUs and AOCs) *previously identified*
  - 1.3.2 PRSs Investigated by the RFI
  - 1.3.3 PRSs Proposed for No Further Action, for Phase II Investigation, or for Corrective Measures Studies

  (This information could be presented in a table instead of subsections.)

2.0 DESCRIPTION OF OPERABLE UNITS AND PRS s INVESTIGATED

- 2.1 History and Description of Operable Unit
- 2.2 Description of PRSs (SWMUs and AOCs)
  - 2.2.1 Physical Description and Operations at the PRSs
  - 2.2.2 Suspected and Known Contaminants
- 2.3 PRS Aggregates and Basis for Aggregation

3.0 DESCRIPTION OF RFI

- 3.1 PRS Aggregate No. 1
  - 3.1.1 Investigation of Health and Safety Risks
    - 3.1.1.1 Methods and Procedures Used For Investigation
    - 3.1.1.2 Surveys, Sampling, and Analysis Performed
    - 3.1.1.3 Results of Sample Analysis
  - 3.1.2 Investigation of Environmental Pathways
    - 3.1.2.1 Methods and Procedures
    - 3.1.2.2 Surveys, Sampling, and Analysis Performed
    - 3.1.2.3 Results of Sample Analysis
  - 3.1.3 Other Data Collection Programs
- 3.2 PRS Aggregate No. 2 (Etc.)

4.0 RESULTS OF INVESTIGATION

- 4.1 PRS Aggregate No. 1
  - 4.1.1 Nature and Extent of Contamination
  - 4.1.2 Environmental Pathways and Potential Receptors
  - 4.1.3 Health Risks and Other Impacts on Potential Receptors
  - 4.1.4 Recommendations
- 4.2 PRS Aggregate No. 2 (Etc.)

5.0 PRS s PROPOSED FOR NO FURTHER ACTION

6.0 PROPOSED PHASE II INVESTIGATIONS

7.0 PROPOSED CORRECTIVE MEASURES STUDIES

APPENDIX A Analytical Results and Data Validation

APPENDIX B Sampling Locations

3.5.2 Requirements for the CMS

This section provides information to satisfy the requirements of Sections K, L, M, N, and parts of O and Q of the HSWA Module. The CMS process will be developed and implemented in accordance with EPA guidance (EPA 1988, 0295).

If required by EPA, DOE/UC will submit for review and approval a CMS work plan (CMS plan) that lays out the activities to be conducted during the CMS. The draft CMS plan is due at EPA within 90 days of notification of the requirement to conduct a CMS. EPA will review and approve the CMS plan or will suggest revisions to DOE/UC.

DOE/UC will begin to implement the study no later than 15 days after receiving written notice that EPA has approved the CMS plan. DOE/UC will conduct the CMS in accordance with the approved CMS plan, and the CMS will include

- evaluating performance of the remedy(ies),
- assessing effectiveness,
- assessing time required for implementation,
- estimating costs for implementation, and
- assessing institutional requirements.

A draft CMS report will be prepared within 60 days after the CMS has been completed. The draft report will be based on the results of the study, evaluating corrective measures and recommending the final corrective measure for the release site or groups of sites. EPA will approve the proposed DOE/UC remedy based on the proposed remedy's ability to meet the criteria established for selecting the remedy. The criteria will be developed through implementation of the CMS process as discussed in the following sections. At a minimum, these criteria will address

- standards for remedies,
- remedy selection criteria,
- schedule for implementing the remedy,
- media cleanup standards, and
- compliance with media cleanup standards.

Because of the wide variety of PRSs at the Laboratory, each study will be tailored to the needs of each site. In many cases, site conditions may not require extensive evaluation of several alternatives. Often, a study as detailed as that discussed in the following sections will not be necessary. In those cases in which the number of possible remedies is limited, the process will be as focused and streamlined as possible, consistent with the nature and extent of contamination, to expedite the cleanup process. In those instances in which there is only one obvious remedy, DOE/UC will propose that single option, which will be a conditional remedy. For example, in-place stabilization with long-term monitoring and institutional controls

will be proposed for several MDAs at the Laboratory. Proposed implementation of a conditional remedy approach is discussed in Section 3.8.

3.5.2.1 Corrective Measures Study Work Plan

The first step in the process of selecting alternatives for remedial action is to prepare the CMS plan. The CMS plan is used to identify and develop a scheme for evaluating alternatives for final remediation of the PRSs. The plan will provide sufficient information to allow EPA to evaluate the appropriateness and adequacy of the activities proposed for evaluating potential cleanup alternatives. The CMS is to be flexible enough to allow evaluation and proposal of only one alternative whenever site-specific conditions permit. Each OU-specific CMS will be unique to the environmental setting and nature of contamination in the unit.

The ER Program will develop an outline for the OU-specific CMS plan as the program approaches the CMS phase and will include it in a later IWP for EPA review and approval. The overall Laboratory RFI/CMS schedule is such that no OUs will be in or near the CMS phase of the process before the mid-1990s. The CMS plan will be consistent with the scope of work for a CMS, Section Q, Task VI, of the HSWA Module. The plan will also be consistent with proposed Subpart S (EPA 1990, 0432), as applicable, and will be incorporated in the IWP when Subpart S becomes final.

At a minimum, the plan will contain

- a description of the general approach to investigating and evaluating potential alternatives (e.g., only reasonable alternatives will be considered);
- a definition of the overall objectives of the study;
- a description of the specific remedial alternatives to be studied;
- a plan for conducting treatability (bench- or pilot-scale) studies to determine the suitability of alternatives for site restoration;
- a plan for evaluating remedial alternatives to ensure compliance with the standards for remedies as specified in EPA guidance;
- a schedule for conducting the CMS; and
- a proposed format for the presentation of the results (CMS report).

In addition to the requirements discussed above, the Environmental Protection Group (EM-8) will review the outline of each CMS plan to ensure that adequate information will be available to determine whether the plan complies with NEPA requirements. DOE/UC propose to integrate RCRA and NEPA compliance through the CMS process. The CMS plan will be used to trigger a determination of whether an environmental assessment (EA) is required. The CMS report will fulfill the requirement for an EA, if an EA is required. In the event that a full environmental impact statement is required, the CMS report will be a support document for that effort. In addition, natural resource damage assessments will be considered during the CMS process.

After receiving written approval of the CMS plan and after the plan has been revised as necessary, DOE/UC will initiate the study within 15 days. The conduct of the OU-specific CMS will comply with the CMS plans approved by EPA, consistent with the scope of work for a CMS provided in Section Q of the HSWA Module, Task VII, and other specified permit requirements. The scope and level of technical detail in the study will be adequate to allow DOE/UC to propose a remedy based on the results of the study and to allow EPA to review and approve that choice. The evaluation of the alternative(s) will be based on technical, environmental, human health, and institutional concerns.

3.5.2.2 Corrective Measures Study Report

Within 60 days of completing the CMS, a draft report will be prepared that summarizes the results of that study. The results of the study will be provided to EPA by the CMS report. The format of the CMS report is not presented here but will be developed as part of the CMS plan. At a minimum, the report will present the evaluation of alternatives consistent with the scope of work for a CMS report described in the HSWA Module.

The primary purpose of the CMS report is to enable DOE/UC to justify and recommend a corrective measure alternative for EPA approval. The report will include a detailed description of the remedies assessed and will describe how the proposed remedy meets the standards for remedies specified in the CMS plan. The primary criteria from which the standards for selecting the remedy will be developed are

- long-term reliability and effectiveness;
- reduction of toxicity, mobility, or volume of contaminants;
- short-term effectiveness;
- implementability; and
- cost.

Within 120 days of receipt of the draft report, EPA will approve or request a revision of the CMS report. EPA's response will consider comments received from NMED and the public. DOE/UC will finalize the draft CMS report, incorporating comments received from EPA within 30 days of receipt.

3.5.2.3 Selection of the Remedy

In selecting a final remedy, the EPA will evaluate the proposed alternative in light of several criteria to determine whether the alternative meets EPA guidance (EPA 1988, 0295). The basic decision factors to be used in this evaluation are discussed in the following sections and include

- general standards for remedies,
- factors considered in selecting the remedy,
- schedule for implementing the remedy,

- standards for cleaning up various media,
- determination that remediation of a release is not required,
- demonstration of compliance with cleanup standards, and
- conditional remedies.

If the selected remedy should leave in place residual contamination that could adversely impact natural resources, the DOE/UC may carry out a natural resources damage assessment under the provisions of CERCLA (EPA 1990, 0559, pp. 8665-8865; DOE 1991, 0560).

3.5.2.3.1 Standards for Remedies

The CMS will generate data sufficient to evaluate potential remedies for their ability to meet the following standards:

- protection of human health and the environment,
- attainment of established cleanup standards,
- control of the source of release, and
- compliance with waste management requirements.

These standards are broad and include the major technical requirements for controlling sources, conducting waste management activities, and cleaning up the environment. Waste management requirements for those sites that require excavation may be met through the proposed MWSDF. The Laboratory will comply with media cleanup standards to the extent practicable. In all cases, however, the overriding concern in selecting remedies will be protection of human health and the environment.

3.5.2.3.2 Decision Factors

In order for DOE/UC to propose and for EPA to select a remedy, five specific criteria will be considered for the four general standards presented above. Because conditions at the OUs vary, the decision factors for each proposed remedy may be weighed differently at different OUs. Tradeoffs may be possible for some factors, but the overriding concern in selecting a remedy is protection of human health and the environment.

3.5.2.3.3 Schedule for Implementing the Remedy

DOE/UC will provide a schedule for implementing the proposed remedy to EPA for approval. As appropriate, the schedule will address the following factors, although additional factors may influence the timing of the implementation:

- extent and nature of contamination,
- DOE/UC's ability to implement the remedy,

- availability of treatment technology,
- desirability of currently unavailable technologies that may offer significant advantages,
- potential risks related to implementation of the remedy, and
- any other relevant factors.

DOE/UC recognize the need for innovative and more cost-effective remedial technologies. New technologies developed at the Laboratory should offer distinct advantages over currently available technologies. Although DOE/UC recognize that work must begin now on new and improved technologies (e.g., downhole monitors and stabilization techniques), it is conceivable that the desired technologies will not be fully developed at the time the remedy is selected. In such cases, DOE/UC may propose that EPA postpone selecting a remedy until these technologies are functional if there is a distinct technical, time, or cost advantage.

3.5.2.3.4 Media Cleanup Standards

Media cleanup standards will define contaminant levels that protect human health and the environment. Existing standards primarily address drinking water. Therefore, DOE/UC will use health-based risk assessments to determine the effort needed to clean up most contaminated soils, sediments, and soil vapor. Factors to be considered in determining cleanup standards include multiple contaminants, sensitive receptors, site-specific exposures, the effectiveness of the proposed treatment, and current and future land uses.

Risk-based determinations will be consistent with proposed Subpart S, which proposes that "cleanup standards for carcinogens shall be established at levels which represent an excess upper-bound lifetime individual risk between 1×10^{-4} and 1×10^{-6}." Cleanup standards for noncarcinogenic toxicants will be established to allow daily exposure without appreciable risk of deleterious effects during a lifetime.

Cleanup levels may be raised or lowered, depending on the circumstances at individual sites. Such circumstances may include a determination that concentration levels of certain contaminants must be lowered to protect human health and the environment, that higher concentrations will be permitted because background levels are elevated, and that groundwater that is not a potential source of drinking water or is not hydraulically connected to a drinking water source need not meet drinking water standards. In addition, the technical feasibility of remediation will be taken into account.

DOE/UC will propose for EPA approval the specifics for compliance with established standards. This proposal will address the point of compliance, monitoring and sampling locations, analytical parameters and methods, statistical analyses, and the period required for monitoring restored sites.

3.5.2.3.5 Determination That Cleanup Standards Cannot Be Met

Some sites at the Laboratory may require cleanup to action levels; i.e., soil excavation, treatment, or some other method that physically removes the contaminant from the environment. However, there are sites at the Laboratory from which it would

be impractical to physically remove all contaminants. Therefore, the definition of cleanup must include other remedies that involve controlling migration of contaminants from a source.

Cleanup refers to any measure taken to ensure protection of human health and the environment, not to total removal of a contaminant. Areas of widespread, very-low-level contamination, such as the canyons that drain the Laboratory site, are locations that may not be required to attain total cleanup. For example, low levels of risk to human health resulting from contamination in local canyons would not be significantly reduced by cleanup because contaminant concentrations are so close to background levels. Thus, cleanup will be approached on a case-by-case basis, and it will be the responsibility of DOE/UC to demonstrate to EPA that remediation would provide no significant reduction in risk.

One of the primary remedial measures that the Laboratory intends to propose for several MDAs is in-place stabilization followed by long-term monitoring and institutional control, when an RFI supports such an approach. Appendix D describes landfill cover technology. This choice would not meet media cleanup criteria because the contaminants would remain in the environment. However, remediation of these large, mixed-waste landfills would be an extremely large, complex, and perhaps risky undertaking. In these cases, DOE/UC intend to propose that technical impracticability precludes attainment of media cleanup standards.

3.5.2.3.6 Demonstration of Compliance with Media Cleanup Standards

DOE/UC will propose for EPA approval several conditions for demonstrating that implementing a remedy complies with the cleanup standards. Those requirements include identifying

- the location where compliance levels must be achieved,
- the sampling and analytical methods that will be used to determine compliance, and
- the length of time that DOE/UC must monitor a site to demonstrate that levels of contamination after cleanup do not exceed standards.

The primary limiting cleanup standards for the Laboratory will be those for soils and sediments. In general, the point of human exposure will be the likely location for demonstrating compliance. However, it may be that the point of compliance for some sites will have to be determined on a case-by-case basis. The program may provide innovative and unique methods and instrumentation for monitoring compliance, including a variety of downhole sensors and high-speed analytical units for use in the field. EPA approval of these methods and instruments for several OUs will be requested in future revisions of this IWP. Approval of those methods specific to an OU will be proposed in the CMS report for the individual unit.

3.5.2.5 Conditional Remedies

When EPA cannot select a final remedy or when DOE/UC and EPA agree that it is in the interest of the environment to delay implementation of the final remedy (e.g.,

to complete technology development or when reasonable DOE disposal capacity is not available), conditional remedies may be proposed and approved. Such remedies include prompt corrective measures that can reduce risk or incomplete cleanup when a total cleanup is impractical. Conditional remedies are appropriate for actively managed, financially viable facilities such as the Laboratory. When a conditional remedy is used, the site must be revisited after a pre-established period to determine whether the remedy can be considered final and certified as complete before terminating the specified schedule of compliance. Several criteria must be met before implementation. These criteria include

- protecting human health and the environment,
- achieving media cleanup standards beyond the facility boundary,
- preventing further significant environmental degradation,
- implementing institutional controls,
- continuing monitoring, and
- complying with waste management standards.

DOE/UC will propose site stabilization and long-term monitoring and institutional controls as a conditional remedy for some of the large MDAs, which are similar to large municipal landfills. The concentrations of contaminants in hazardous materials in the MDAs that meet criteria for conditional remedies do not currently threaten human health. Institutional controls currently provide long-term control of access and prevent potential exposure of Laboratory workers. The potential for contamination of the main aquifer is limited throughout the Laboratory site and is even more limited at the MDAs. For these reasons, DOE/UC believe that site stabilization and institutional controls will protect human health. Long-term monitoring will be conducted as necessary.

As practicable, the conditional remedy will be identified in the RFI work plan, and data collection will focus on obtaining information adequate to evaluate the effectiveness of the likely remedy. The RFI will be structured to support the ultimate selection of the proposed remedy. When possible, a treatability study will be incorporated in the RFI work plan, and the findings of that study will be presented in the RFI report. Data generated through the RFI will provide EPA with a basis for selecting a remedy sufficient to protect human health and the environment. When the results of the RFI support a single obvious remedy, which could include extensive pilot testing, a formal CMS will not be conducted but the proposed remedy will be presented to EPA as part of an RFI report. Based on the results of the RFI, DOE/UC will request that the permit be modified to allow a conditional remedy. Upon EPA approval, DOE/UC will prepare a CMI plan for implementing the remedy. The CMI plan will provide for obtaining information adequate to design and implement the remedy, maintenance plans, schedule, QA program, progress reports, and a proposal for determining a complete and final remedy.

Because DOE/UC intend to propose in-place stabilization with long-term monitoring and institutional control as a remedial alternative for some PRSs, it is acknowledged that, to ensure compliance, sensitive and dependable instruments will be required for long-term monitoring; therefore, DOE/UC have initiated several efforts to develop

appropriate equipment, such as polymer film field sensors, optical fiber-flow optrode, fieldable Raman with fiber optics, and tritium plume detectors.

DOE/UC realize that conditional remedies may not be final remedies; therefore, they propose that the remedy decision be reviewed after a period of implementation to compare the performance of the conditional remedy with established remedy standards. The conditional remedy may be declared the final remedy at that time, or EPA may require further corrective action to supplement or replace the conditional remedy. Final selection of the remedy and termination of the permit will comply with the procedures described in Section 4.5.

3.5.2.6 Permit Modification for Selection of the Remedy

The preliminary selection of the remedy based on EPA's response to the CMS report will be finalized by a major modification of the schedule of compliance given in the HWSA Module. The EPA will modify the permit to specify the remedy selected through the CMS process. The permit modification will be conducted according to the procedure established in Section N of the HSWA Module. The modification process will include a formal public comment and revision period before the written notice of the permit modification is issued, not before reissuance of the permit.

The remedy specified may be separated into phases, and the proposed modification will include

- a description of the technical features of the remedy;
- the media cleanup standards established through the CMS process;
- requirements for achieving compliance with media cleanup standards;
- requirements for complying with waste management standards, land disposal restrictions, etc.;
- requirements for final disposition of the equipment used to implement the remedy;
- schedule and major milestones for implementing the remedy, including submission of the CMI plan; and
- reports and documentation to be submitted by DOE/UC during the implementation of the remedy.

3.5.3 Requirements for the CMI

DOE/UC will prepare a CMI plan after approval of the permit modification and upon request of EPA. The outline for the DOE/UC CMI plan has not been developed but will be submitted for approval in a future revision of this IWP. In general, the CMI plan will include

- remedy design; i.e., detailed construction plans and specifications to implement the selected remedy;

- type and frequency of reports to be submitted on the progress of implementation;
- type of EPA reviews of implementation;
- requirements for completion of the remedy;
- determination of technical impracticability; and
- verification plans.

3.5.3.1 Remedy Design

The CMI plan will contain a section that provides detailed construction plans for implementing the remedy. In some cases, the technical details may have been provided in the CMS report. The CMI plan may cite those specifics and propose to EPA that they be adopted in the final design. In either case, EPA approval of the CMI plan will constitute approval of the remedy design and schedule. The remedy design should include

- design specifications for PRSs,
- implementation and long-term maintenance plans,
- major milestones,
- project schedule, and
- a QA plan for the construction.

EPA will approve or revise the CMI plan, and DOE/UC will implement the remedy as approved. The approved CMI plan will be placed in the ER Program's community reading room (Annex V). DOE/UC will provide written notice of the availability of the approved plan to all individuals on the ER Program mailing list. In addition, the cost estimate provided in the CMS report will be revised as necessary.

3.5.3.2 Progress Reports

DOE/UC will submit quarterly technical progress reports as required by the HSWA Module. Depending on the type of remedial action being implemented, it may be necessary to provide frequent and detailed information about the effectiveness and progress of the remedy. The data on which the reports are based are maintained in the Records-Processing Facility and are available for public review.

The schedule and content of the progress reports will be developed in the CMI plan and will thus be tailored to each OU. The reports may include

- summaries of progress,
- problems encountered and resolutions,
- personnel changes,

- upcoming work for the next reporting period, and
- laboratory and field sampling reports.

3.5.3.3 Review of Remedy Implementation

EPA will periodically review the progress of the remedy and may recommend modification of the schedule of compliance or additional remedial measures. The reviews may consist of reviews of the progress reports and visits. Because each remedy will require varying levels of EPA oversight, CMI plans will be tailored to each site according to the level of review and progress evaluation required.

3.5.3.4 Completion of Remedies

The CMI plan will contain the criteria to be used to demonstrate completion of the remedy. Upon completion of the remedy, DOE/UC will submit a request for termination of the schedule of compliance for the corrective action. The request will contain a certification that DOE/UC have met or exceeded all of the criteria established for this purpose. The request to EPA will include verification that

- all media cleanup standards have been achieved,
- actions required for source control have been satisfied, and
- procedures for final disposition of equipment and materials associated with the remedial action have been followed.

EPA will review the request, along with public comments, to determine whether the remedy has been completed in accordance with the requirements of the HSWA Module and CMI plan. After such determination, the EPA will modify the HSWA Module to terminate the schedule of compliance for the corrective action (Section 3.11).

3.5.3.5 Determination of Technical Impracticability

For numerous reasons, it may be technically impractical to achieve compliance with the requirements for the remedy. DOE/UC expect to minimize such situations through the use of new and innovative remedial technologies developed by and for the Laboratory. However, if compliance is impossible for technical reasons, DOE/UC will propose that EPA modify the permit so that additional or alternate methods may be used. This approach will be developed further in an update of this plan.

3.6 Other Requirements

3.6.1 Coordination of Corrective Actions with Resource Conservation and Recovery Act Closures

Several SWMUs listed in the HSWA Module are subject to both the corrective action and closure provisions of RCRA (e.g., RCRA hazardous wastes were intentionally managed at these sites after November 19, 1980). DOE/UC will manage all of these sites in a manner consistent with the management of all of the other PRSs listed in

the Laboratory's PRS data base. As a result, the corrective action process will occur concurrently with the closure process, thereby satisfying both sets of regulations. It is understood that the NMED will maintain its role as the lead regulatory agency for these sites in spite of the change in approach.

DOE/UC will implement this strategy for several reasons: (1) The RFI/CMS portions of the corrective action process ensure that releases are identified and mitigated as part of a final remedy (simple compliance with closure standards does not always guarantee mitigation). (2) The strategy allows for a consistent, coherent approach to environmental restoration (e.g., some OUs currently contain PRSs subject only to RCRA corrective action and PRSs subject to both corrective action and closure). (3) This strategy prevents duplication of effort. (4) The strategy is consistent with the preamble to proposed Subpart S, which states EPA's intent to allow extension of closure deadlines as necessary to complete corrective actions.

The OUPLs will incorporate the closure sites in RFI work plans. The final remedy for these sites will be consistent with closure performance standards, and postclosure monitoring will continue if waste remaining in these sites releases concentrations of contaminants that exceed closure standards.

There are two categories of closure sites: (1) sites at which field work has been initiated or completed and (2) sites at which work has not been initiated. For those sites at which closure activities have already been initiated (either under an approved closure plan or in accordance with institutional controls before a closure plan has been approved), DOE/UC will complete closure activities according to the standard approach and will document the work in the RFI work plans as voluntary corrective actions (VCAs). Because DOE/UC intend to close all of these sites in clean condition or to acceptable risk-based criteria, the RFI work plans will probably not recommend further action. Except for the TA-40 scrap detonation site, which will be cleaned to acceptable risk-based criteria, sites at which corrective action has not yet been initiated will follow the integrated approach outlined above, which will involve delaying completion of closure activities until the RFI/CMS process has been completed. DOE/UC will pursue a letter of agreement with the state that delays at these sites are acceptable, thereby eliminating the need to revise existing closure plans.

3.6.1.1 Surface Impoundment for Burning Ground at TA-16

The approved closure plan for this task was received from the NMED on February 21, 1990, and the closure was completed on September 20, 1990, according to the mandated schedule. To adhere to the strategy outlined above, the closure report will be used for justification to remove the site from further consideration because it has met the cleanup requirements for a RCRA closure.

3.6.1.2 TA-35 Waste Oil Storage Pits

The DOE/UC submitted closure plans for two waste oil pits (#85 and #125) at TA-35 in October 1988, and NMED gave oral approval to proceed with closure activities. In late March 1989, the contents of the pits were removed for incineration. In April, samples of the underlying soils at #125 obtained by chiseling through the liner showed contamination. Discussions between the Laboratory and NMED indicated that a clean closure could be achieved, even if residual contamination remained in place, provided that residual contaminant levels were below a health-based limit.

NMED agreed to leaving the contamination in place and calling it a "clean closure" if the Laboratory would restore the site to less than 1 ppm (volatile and semivolatile organic compounds) and would prove that the residuals were not a threat to human health. This strategy was adopted, and the closure, including backfilling, was essentially completed early in FY90.

Samples were taken during excavation to determine whether the contaminant levels in the remaining soil were acceptable. A review of the sampling results, however, indicated some weaknesses. First, holding times were exceeded for some of the volatile constituents. Second, detection limits for some analyses were skewed because of the presence of waste oil. Hence, a second set of verification samples was obtained in FY91 by drilling through the fill. The purpose of the second analysis was to determine the extent of contamination caused by waste oil (total hydrocarbons from petroleum) and to duplicate the analyses of volatile and semivolatile components. The second analysis showed no evidence of contaminants present above analytical capabilities, natural background levels, or health-based action levels for cleanup. In response to a request from NMED, the Laboratory delivered a sampling plan for the canyon south of the former location of Surface Impoundment TSL-125. The plan was submitted September 4, 1992, and the Laboratory is awaiting approval of this plan before proceeding.

The closure plan for this site has been updated to reflect activities that actually occurred in the field. The RFI work plan for TA-35 (OU 1129) reported these activities as VCAs performed for two SWMUs at TA-35. Because the corrective actions will result in a clean closure, the RFI work plan did not recommend further action.

The closure report and closure certification letters for the TSL-125 waste oil surface impoundment were completed as of July 31, 1991, and were submitted to NMED in August 1991. The closure report and closure certification letters for TSL-85 were submitted December 20, 1991. DOE/UC are awaiting regulatory approval from NMED for both of these closures.

3.6.1.3 TA-16 Area P Landfill

The closure of Area P presents a significant technical challenge. Clean closure seems impractical at this site, but it would also be difficult to encapsulate the landfill because it is located on a canyon rim. The existing closure plan, submitted in November 1985 and supplemented in 1987, proposed leachate collection and partial encapsulation. The Laboratory has asked that the NMED not approve the existing closure plan because of the need for additional data to support and ensure the selection of the best closure alternative.

This site is an excellent example of the need for the integrated approach discussed above. In this case, a thorough RFI/CMS will resolve any outstanding issues and will lead to implementation of the most protective, cost-effective solution. The RFI/CMS could include a series of studies, including (1) an analysis of existing data and a proposal to define the extent of barium contamination, (2) an engineering study to develop the most effective cap design, and (3) bench-scale studies to determine the potential effectiveness of in-situ chemical fixation and/or leaching.

Thus, each of the RFI/CMS documents prepared during implementation of the corrective action process for TA-16 would be submitted to NMED as modifications of, or supporting information for, the existing, unapproved closure plan. Approval of

the final closure plan could then occur when the NMED agrees with the corrective action alternative indicated in the CMS. NMED has agreed to this strategy.

3.6.1.4 TA-40 Scrap Detonation Site

The original closure plan for this site (amended December 1985) implied an intention to use the scrap detonation site as an active firing site, but the goal has changed to clean closure with no further use. In FY90, the ER Program Office prepared an updated closure plan. The revised closure plan was submitted as an amendment to NMED in November 1990 and was approved with an official start date of September 30, 1991. This closure is proceeding four months behind the schedule in the approved closure plan because the NEPA documentation was held up at DOE/HQ.

3.6.1.5 TA-54 Areas H, L, and G

Certain trenches, pits, and shafts in Areas H, L, and G qualify as hazardous waste landfill cells subject to partial closure. However, other units in these areas last received hazardous waste before 1980 and are therefore subject to corrective action under RCRA Section 3004(u). Thus, two different sets of cleanup regulations apply to units that are similar in content and geographic location.

The situation at TA-54 is similar to that at the Area P landfill, where the integrated approach is most appropriate, and TA-54 will be treated similarly. Although two separate closure plans have already been submitted, one for Areas L and H and one for Area G, an agreement with NMED will delay implementation until the RFI/CMS has been completed and the closure plan has been revised.

3.6.1.6 TA-54 Area L Waste Oil Storage Tanks

With the oral approval of NMED, six aboveground storage tanks containing waste oil were pumped out in FY89 and were moved from Area L to Area G to make room for new facilities. Although closure of these tanks was originally scheduled that same year, it was delayed to FY90 because NMED had not approved the closure plan in FY89.

In order to decontaminate the tanks as quickly as possible, it was decided that the tank closure would not include any associated contaminated soil that may exist in Area L; any of this contaminated soil would be treated during closure and corrective action at Area L. The decontamination of these tanks was completed in FY90, and a closure report was submitted to NMED in June 1991. The closure report documented the work as it actually occurred in the field and will be used in the RFI work plan for OU 1148 to justify recommending the tanks for no further action. The contaminated soil will have to be characterized and possibly cleaned up.

3.6.2 Interim Remedial Measures

The HSWA Module provides for interim remedial measures (IRMs). The paragraphs below discuss the two types of IRMs to which EPA refers in Section I of the HSWA Module. The DOE/UC will modify this section to make it consistent with the VCA provisions in the preamble to proposed Subpart S.

3.6.2.1 Interim Remedial Measures Based on Health Risks

If EPA determines that a release of hazardous waste or its constituents poses a threat to human health or the environment, it may mandate that DOE/UC implement IRMs to mitigate the risk. EPA may also specify a schedule (by modifying the HSWA Module) for implementing the interim measure and may require the Laboratory to prepare and submit a work plan to be approved before action is initiated. To date, EPA has not required the Laboratory to take any IRMs because no imminent threats to human health or the environment have been identified. However, in the unlikely event that EPA requires an interim measure in the future, DOE/UC would modify the work plan. DOE/UC may at that time request EPA to modify the schedule of compliance for the corrective action.

In determining the need for IRMs based on health risks, at least the following factors will be considered:

- the time required to implement a final remedy,
- actual and potential exposure of human and environmental receptors,
- actual and potential contamination of drinking water supplies and sensitive ecosystems,
- the presence of hazardous waste that may pose a threat of release,
- the presence of hazardous waste or constituents in soil that have the potential to migrate to groundwater or surface water,
- weather conditions, and
- risks of fire, explosion, or accident.

3.6.2.2 Interim Remedial Measures Based on Institutional Needs

Other IRMs referred to in the HSWA Module are triggered by institutional need. The HSWA Module states, "If, for institutional reasons not related to permit work, i.e., routine construction, an interim measure is required, the permittee will submit appropriate documentation to the Administrative Authority (EPA) for approval." DOE/UC will conduct interim measures based on institutional needs consistent with the proposed Subpart S provisions concerning VCAs. VCAs will be discussed in the quarterly public meetings. VCA documentation will be submitted to EPA in quarterly technical progress reports and other appropriate documents. When a VCA serves as the final remedy, a request for a formal permit modification for no further action will be made.

The institutional need for IRMs at the Laboratory has been and will continue to be associated with construction projects, routine maintenance, and other activities. The Laboratory identifies the need for such actions during the normal review process used by the EM Division to ensure that construction projects comply with environmental and safety laws, DOE orders, and Laboratory policies. Engineering Division construction project managers are responsible for ensuring that their plans are

submitted to EM for review before implementation. A central point of contact for construction project managers has been established in HS-3, from which plans are directed to the various organizations in EM responsible for ensuring compliance with various laws and regulations The ER Program Office is one of these organizations and is responsible for ensuring that construction project managers are informed when their projects overlap with an identified PRS or area potentially influenced by a PRS. OUPLs are also informed when there is likely to be construction work that might affect any of the PRSs in their operable units.

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4.0 TECHNICAL APPROACH

This chapter presents the technical framework within which the corrective action process under way at Los Alamos National Laboratory (the Laboratory) is being conducted in accordance with the Resource Conservation and Recovery Act (RCRA) as amended by the Hazardous and Solid Waste Amendments (HSWA). Because it is the Department of Energy (DOE) and the Laboratory's policy to comply with the Comprehensive Environmental Response and Compensation Liability Act (CERCLA) as well as with RCRA requirements, this technical approach includes elements of the CERCLA process as well as RCRA methods. In particular, this RCRA-based approach is applicable to all potential release sites (PRSs), including those that are not subject to the provisions of the HSWA Module (the portion of the Laboratory's permit that contains requirements specific to the Laboratory).

The Environmental Restoration (ER)Program at Los Alamos has determined that a risk-based approach to making decisions during the corrective action process is appropriate, given the great variety of PRSs that have been identified and the complexity of the natural environment on the Pajarito Plateau. In addition, the framework must provide for early identification of important problems and for assigning priorities to all PRSs at the Laboratory so that corrective actions can be implemented in a timely fashion. Finally, program decisions entail significant monetary, social, and legal consequences that must be incorporated in a technical framework.

Strategies composing a technical approach designed to satisfy the above criteria are described in the following sections. Section 4.1 describes the process for making corrective action decisions, including designing field investigations to support those decisions. Section 4.2 describes the criteria that will be applied to making decisions during the course of site investigations and during the design and implementation of corrective actions. Section 4.3 outlines the ER Program's approach to risk assessment. [Only human health risk assessment is discussed in this revision of the Installation Work Plan (IWP). The Los Alamos ER Program plans to include a discussion of ecological risk assessment in future versions of the IWP.] Sections 4.4 and 4.5 provide brief surveys of techniques for site characterization and alternatives for corrective action that may be considered during the investigative and remedial stages of the program, respectively.

Defined below are several terms used frequently in this chapter that carry meanings specific to the ER Program decision processes and to risk assessment. Additional definitions may be found in the glossary at the end of this document.

Baseline risk assessment A risk assessment conducted using an appropriate, site-specific exposure scenario but assuming no mitigating or corrective measures beyond those already in place.

Administrative controls to be considered? How is this a realistic scenario?

Background levels The distribution of concentrations of naturally occurring or widely distributed constituents in environmental media.

Contaminant, contaminant of concern Any constituent present in environmental media or on structural debris at a concentration above its screening action level (SAL).

Constituent Any compound or element present in environmental media, including both naturally occurring and anthropogenic elements.

Cleanup levels Media-specific target concentration levels for constituents that must be met by any corrective action selected. Cleanup levels are established during corrective measures studies (CMS) using selection-of-remedy criteria such as protection of human health and the environment; compliance with regulatory requirements; reduction of toxicity, mobility, or volume through treatment; long- and short-term effectiveness; implementability; cost; and public acceptance.

CMS risk assessment A risk assessment conducted using an appropriate, site-specific exposure scenario to estimate risk reduction following the implementation of corrective measures.

Deferred investigation Postponement of complete evaluation of a PRS, which may be proposed when investigation would have negative impacts on current Laboratory operations when it is determined than the site presents no current risk to human health or the environment.

Environmental medium Any medium capable of absorbing or transporting constituents released from a PRS, including tuffs, soils and sediments derived from these tuffs, surface water, groundwater, air, structural surfaces, and debris.

No further action (NFA) One of the possible end points of the corrective action process: a decision that no further investigation or remediation is warranted for a PRS. No further action may be proposed during the RCRA field investigation (RFI) of a PRS if it is determined that no release with potentially significant risk to human health or the environment has occurred.

Regulatory standard, regulatory concentration criteria Media-specific contaminant concentration levels of potential concern that are mandated in specific pieces of federal or state legislation (e.g., the Safe Drinking Water Act, New Mexico Water Quality Control Commission regulations).

Risk assessment An assessment of the potential human health or environmental risk associated with contamination of environmental media. Risk assessment includes hazard identification, exposure assessment, and dose response analysis. For human health risk assessments, two end points are generally estimated: (1) excess lifetime cancer risk and (2) noncarcinogenic toxicological impacts.

I TAKE IT SAL's are

Screening action levels Media-specific concentration levels for constituents derived using conservative criteria. The derivation of SALs is most often based on low risk under a very restrictive exposure scenario, but if a regulatory standard exists and is lower than the value derived by this risk-based computation, it will be used for the SAL.

Screening assessment Evaluation of information about a PRS to determine whether hazardous or radioactive constituents are present above the levels of concern defined by media-specific SALs or regulatory standards.

Voluntary corrective action (VCA) Selection and implementation of an obvious and effective corrective action during or following the RFI.

4.1 RFI and Corrective Action Strategies

4.1.1 Decisions During the RCRA Process

The RCRA process outlined in Chapters 1 and 3 is designed to generate and implement appropriate decisions concerning corrective actions for PRSs at the Laboratory. The principal decisions required during the RCRA process concern potential corrective actions. These remediation decisions demarcate the three stages of the process illustrated in Figure 1-1. Among the decisions that are required by the conclusion of the RFI stage are

- determining whether corrective action is required for the site and
- determining whether a formal CMS is required to select and design an appropriate corrective action.

If a CMS is required to evaluate remedial alternatives, it includes additional decisions, such as

- determining cleanup standards for contaminated environmental media and
- selecting and designing a corrective measure to meet these standards.

The corrective measure is implemented during the third stage of the corrective action process, corrective measures implementation (CMI). The principal decisions during this stage concern verifying the completion and effectiveness of the remedy.

Other options available at the end of the RFI take the corrective action process outside of the flow shown in Figure 1-1. These options include

- proposing NFA;
- deferring action, and often deferring investigation as well, until an active site becomes inactive; or
- VCA.

NFA may be proposed for administrative reasons (the PRS was incorrectly listed, corrective action is being or will be undertaken outside the ER Program, etc.) or following a determination that there are no human health or environmental risks associated with the site. If the PRS is listed in the HSWA Module, the Laboratory will propose delisting following the procedures described in the HSWA Module. DOE and public review procedures comparable to those in the HSWA Module will be followed for other PRSs for which NFA is proposed.

Deferred investigation is the postponement of site evaluation at a PRS that is either itself an active operational site or else is so closely associated with an active site that immediate investigation would negatively affect current Laboratory operations. A proposal for deferred investigation must be accompanied by a determination that the

PRS poses no unacceptable current risk to human health or the environment. Proposals in the RFI work plan to defer investigation are subject to EPA approval.

VCA is an expedited remediation option described in proposed Subpart S to RCRA (EPA 1990, 0432). A decision to proceed with a VCA may be made at any time during the RFI when an obvious and effective remedy is available and meets treatment and disposal restrictions and other limiting criteria. Implementing a VCA may require a change control with DOE approval, and VCAs on sites that contain mixed or land-disposal-restricted wastes may not proceed without a plan for storage and/or disposal of these wastes that has been approved by DOE and the appropriate regulatory agencies. In particular, VCAs that will produce mixed waste will be postponed until the Mixed Waste Storage and Disposal Facility is available unless the site is off DOE property or poses an immediate health hazard. VCAs will be described in technical quarterly reports to EPA, and the public will be informed of VCAs in quarterly public meetings, but the ER Program will not formally solicit EPA approval until the time it requests final approval of the cleanup.

4.1.2 The Streamlined Approach to Environmental Restoration

DOE's streamlined approach for environmental restoration provides a starting point for a technical approach to support the decisions outlined above. The streamlined approach combines elements of the observational approach (Appendix G) and EPA's data quality objectives (DQO) process for designing data collection to support environmental decision making. The streamlined approach implements many of the suggestions for improving the CERCLA process that evolved from an EPA review of early Superfund projects (EPA 1987, 0821).

This approach implements a program of phased site characterization that continues beyond the RFI into the corrective action stages of the process. The phased approach expedites corrective action by progressing to the later steps of the RCRA process as soon as possible. Although understanding of the site may change somewhat as more site detail is revealed by CMI activities, reasonable deviations can be accommodated by careful contingency planning during the CMS and site monitoring during the CMI. Following the streamlined approach, the goal of the RFI is to characterize the site sufficiently to design a corrective measure with contingencies that can effectively accommodate reasonably likely deviations. More detailed characterization may be carried out during the CMI.

Figure 4-1 shows the overall logic flow for an RFI conducted using the streamlined approach. The first step consists of evaluating the existing information about a PRS:

- reviewing the operations that created the site;
- constructing a preliminary conceptual exposure model to summarize current knowledge about potential contamination at the site, potential migration pathways through the environment, and potential receptors; and
- outlining possible response actions.

Depending on the nature of the site and the quality of this information, it may be possible to proceed immediately to one of the end points of the process: a proposal for NFA or VCA or a decision to defer investigation until closure of an associated

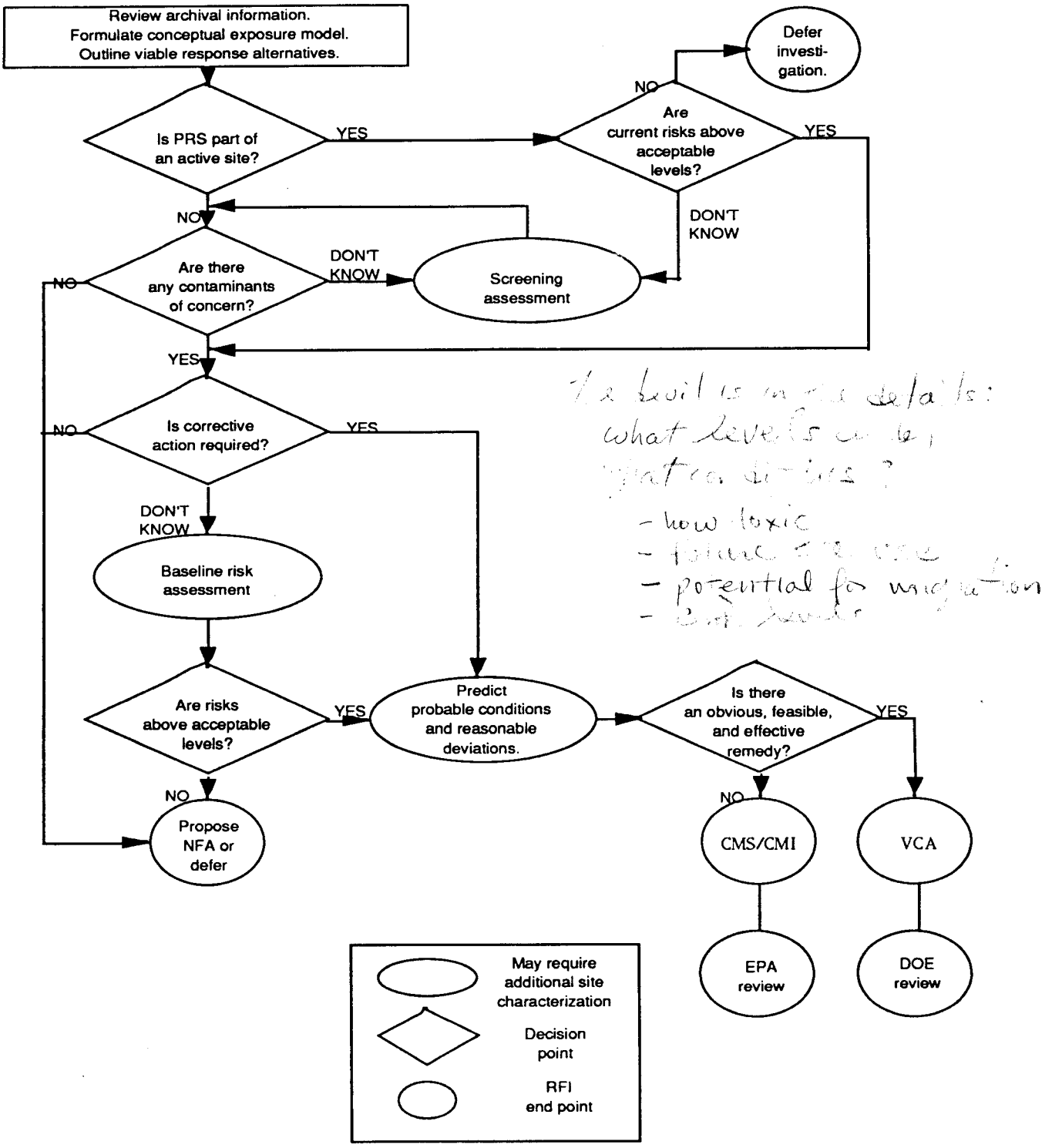

Figure 4-1. Decision flow during the RFI.

active site. If it is known that corrective action will be required and that the site is sufficiently characterized, it may be possible to proceed to the CMS stage without further investigation.

In general, however, the site will require RFI site characterization. Figure 4-1 shows three different RFI activities that might require collecting new data: screening assessment, baseline risk assessment, and establishing probable conditions and reasonable deviations before VCA or CMS. For many PRSs, the first phase of the investigation is a screening assessment (Section 4.1.4). If the contaminants of concern have been identified by previous work or can be determined from archival information, it may be possible to skip the screening assessment and design the first phase of the RFI work to support baseline risk assessment or to complete the description of probable site conditions preparatory to corrective action.

The design of a field investigation is tailored to the decision required. A tool for ensuring that the investigation will produce data of the required types, quantity, and quality is the DQO process (EPA 1987, 0086). An explicit problem statement, together with a list of specific decision alternatives, is central to the process.

Formulating an appropriate problem statement requires evaluating the current state of knowledge about the site. This evaluation is the first step of the seven-step DQO process outlined by the EPA (1991, 0813) and discussed in Appendix H. At the beginning of the RFI, archival information is used to construct a preliminary conceptual model for the problem. For Phase II and subsequent investigations, this step updates the conceptual model using data from previous RFI phases. Step 2 of the DQO process generates the specific problem statement and decision alternatives. Subsequent steps specify an appropriate sampling strategy, stating precisely what is to be measured and where and how the data will be used to support the decision. The final step of the process is the design of a sampling and analysis plan that will provide the required information.

Although not all of the PRSs in the ER Program require that DQOs be developed following an extended formal process, the products of this process—a clear problem statement, well-specified data needs, and a method for using the data to solve the problem—are essential to ensuring that field investigations produce the necessary information. The statistical aspects of the DQO process are further discussed in Appendix H.

4.1.3 Sampling Decisions in a Phased Investigation

The remediation decisions outlined in Section 4.1.1 must be supplemented by sampling decisions. The phased approach illustrated in Figure 4-1 helps to ensure that these decisions remain closely tied to selecting an appropriate corrective action and that they are formulated in light of what is already known about the site.

The first phase of RFI field work, for which detailed sampling and analysis plans are written into the RFI work plan, is usually designed to provide a basis for the first decision in the flow of Figure 4-1 that cannot be made on the basis of existing information alone. For many of the Laboratory's PRSs, this decision turns out to be the question: are there any contaminants of concern associated with this site? This question is answered by a screening assessment.

The goal of an RFI investigation to support screening assessment is to detect contamination if it is present either at the PRS or outside of some perimeter around

the PRS. Sampling for this purpose may be biased toward the areas or media that are most likely to be contaminated.

Investigations to support risk assessment generally require samples that are representative of the exposure units and contact media corresponding to the land use scenario and exposure routes for which risk is to be estimated. If the exposure scenario involves receptors located at the site, estimates of the mean contaminant levels over appropriate exposure units are required. For receptors off the site, mean contaminant levels at points removed from the source in space and time must be estimated, and it may be necessary to characterize potential environmental transport pathways or potential receptors, as well as the level and extent of contamination at the site. An upper confidence bound on the estimated risk is usually used as a test statistic, and large sample sizes may be required to improve the precision of this estimate.

If corrective measures are necessary, additional site characterization may be required to identify the most probable site conditions, together with deviations from those conditions that may reasonably be anticipated. The goal of such additional sampling is often improved understanding of the spatial distribution of the contaminants (in particular, the location of "hot spots") or the identification of all hazardous constituents so that removed material can be properly treated or stored.

Two possible sampling decisions are actually decisions not to sample. NFA may be proposed based on archival information. Deferred investigation may be proposed for a PRS when corrective action, if necessary, will be postponed until an associated active site is closed, or it may be proposed for a site where VCA is planned. For some of these sites, an RFI screening assessment may be appropriate to establish that the site presents no current risks to human health or the environment or to eliminate unpleasant surprises, such as the discovery of a large organic vapor plume under an old septic tank at a site where VCA is proposed.

Site characterization to detect deviations from probable conditions is handled by appropriate monitoring of the site during the CMI. Site monitoring may include in-situ measurement, sampling, or both. The goal of monitoring and hence its design depend on the context within which it is used, but timely data analysis and predefined responses to potential anomalous observations are two important components of any monitoring plan.

Sampling to verify the attainment of cleanup standards is the final step in many corrective actions. In some respects, verification sampling is far more straightforward than sampling for site characterization; in particular, simple random sampling or grid sampling is usually entirely appropriate. Excellent guidance on sampling decisions of this type is found in EPA guidance documents (e.g., EPA 1989, 0794).

Appendix H describes the statistical aspects of some of these sampling decisions.

4.1.4 Screening Assessment

The goal of screening assessment (Figure 4-2) is to identify contaminants of concern, that is, constituents whose concentration levels in one or more environmental medium are above a level of concern defined by media-specific SALs. Although the derivation of SALs is frequently based on risk calculations (Section 4.2.2), these calculations use very conservative assumptions. Baseline risk assessments, on the other hand, use site-specific land use scenarios and exposure assumptions for the

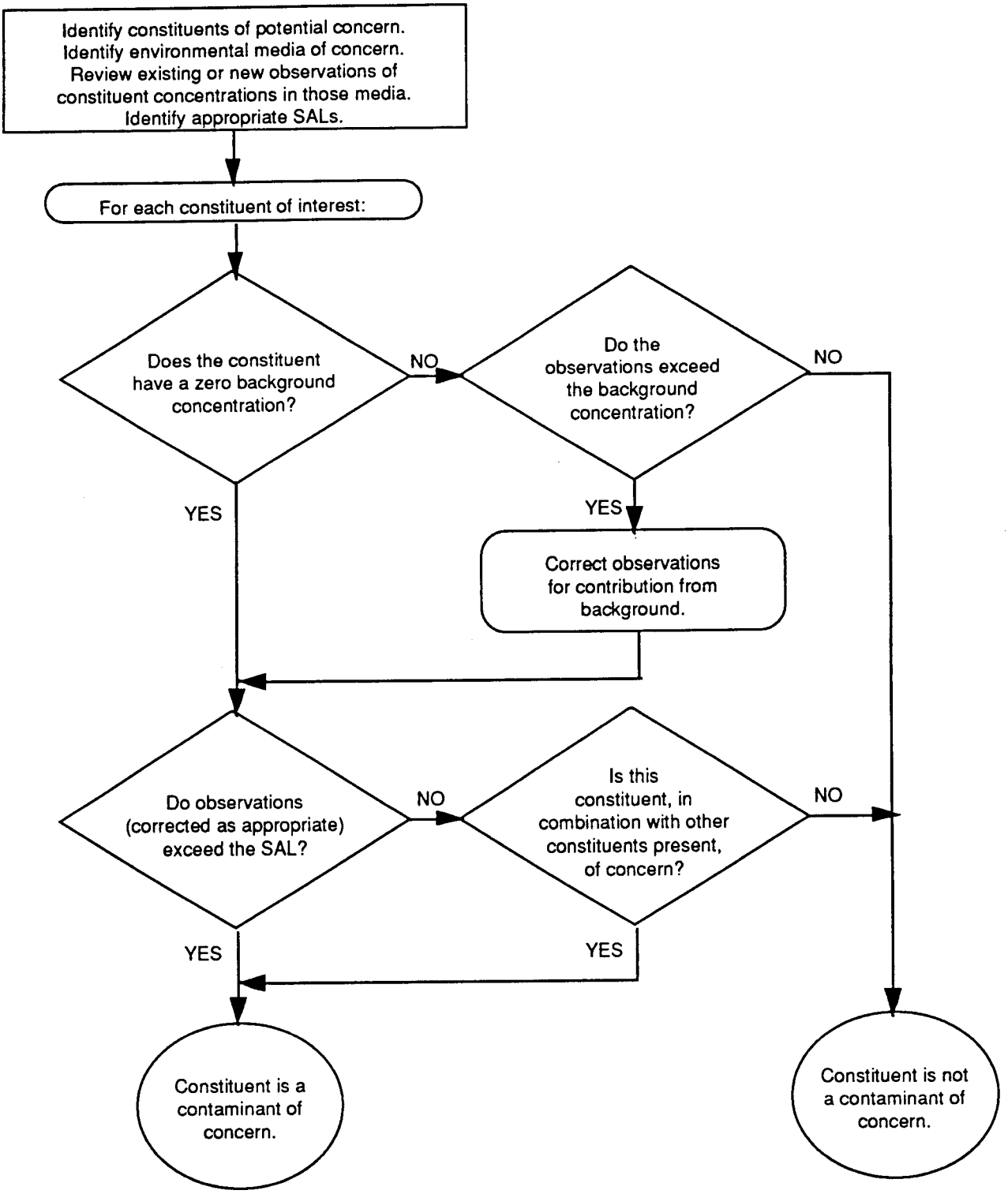

Figure 4-2. Decision logic for screening assessments.

individual with reasonable maximum exposure to estimate the risks associated with the observed contaminants of concern (Section 4.3).

The starting point for a screening assessment is the identification of constituents and environmental media of potential concern, based on knowledge of the process or processes that occurred at the PRS. Elimination of constituents from further consideration should be justified by reference to these processes. Screening for the identified constituents is then carried out using either existing data or new data collected during the RFI. It is also essential to identify appropriate SALs in advance, because the data, whether old or new, must be collected using procedures whose detection levels are below these limits.

Direct comparison of observed constituent concentrations with SALs is complicated for a handful of constituents because they are present in environmental media independently of Laboratory activities. These constituents are said to have positive or nonzero "background concentrations." At Los Alamos, constituents with positive natural background concentrations include many metals in the tuffs of the Pajarito Plateau and the soils and sediments derived from those tuffs. Anthropogenic background constituents include low levels of radionuclides from worldwide fallout. The background concentrations of radionuclides are well documented in existing literature. The ER Program's framework studies are currently collecting data to estimate background distributions for other constituents.

When background concentrations and variability are far lower than SALs, they may be ignored. However, observations of other background constituents must be corrected for the background contribution. In general, a set of observations must be compared with the background distribution in more than one way. The observations could fail to resemble the background distribution because they are uniformly a little large or because there are one or two observations that are outside the common background range. In either case, it is appropriate to decide that "the observations exceed the background concentration" in the decision flow of Figure 4-2.

SALs are intended to be applied to the increment in the concentration of a constituent contributed by the PRS, and thus the observations of background constituents must be corrected for the background contribution before they are compared with the SALs. This correction is generally accomplished by subtracting the mean or the median of the background distribution.

The principal test carried out during a screening assessment is the comparison of the observations (corrected, if necessary, for the background contribution, as described above) with SALs. If the SALs are not exceeded, then again the site may be a candidate for NFA; however, in this case, some additional site evaluation may be required. In particular, if two or more constituents are present, further evaluation is needed to determine their combined effects, which could be significant even though individually the constituents pose no risk. For noncarcinogenic constituents, a hazard index may be used to ensure that no significant constituents are eliminated as contaminants of concern. The combined cancer risk from multiple radiological and carcinogenic constituents will also be assessed (Appendix J).

Constituents whose concentrations exceed the corresponding SALs or that are included because they are significant in combination with other constituents are designated as contaminants of concern requiring further evaluation and possibly remediation.

4.2 Evaluation Factors and Criteria

Section 4.2.1 describes the key factors to be considered in making sampling and remedial decisions. Among the concerns underlying these factors, risks to human health and the environment are of primary interest. Risk assessment (Section 4.3) will be used both during the RFI and during the later stages of the process. For the initial phase of the RFI, however, it is important to have simpler criteria that can be used to screen and prioritize the PRSs at the Laboratory. These criteria take the form of media-specific SALs (Section 4.2.2) against which environmental data can be compared directly. During site cleanup, it is also necessary to have media-specific criteria for evaluating progress (Section 4.2.3).

4.2.1 Evaluation Factors for the Laboratory's ER Program

In the Laboratory's ER Program, criteria used to evaluate decisions are based on common sets of evaluation factors. The five major categories of concern for the Laboratory's ER Program are the same categories used by the Laboratory for many other decisions:

- impacts on human health and safety,
- environmental risks,
- impacts on the social and economic well-being of both the local community and the general public,
- management concerns related to compliance and operations, and
- monetary costs.

The HSWA Module of the Laboratory's RCRA permit (EPA 1990, 0306) and the DOE Office of Environmental Restoration and Waste Management explicitly state that the primary concern of the ER Program will be impacts on human and environmental health and safety, that is, the first two categories listed above. These priorities are reflected by the technical approach adopted throughout the ER Program.

For the ER Program, human health and safety include impacts on both site workers and members of the general public. Public and worker health effects are commonly estimated by risk assessment relative to two end points: excess lifetime cancer risk and noncarcinogenic toxicological impacts. Safety impacts are most often estimated for site workers; however, for some sites, such as those where undetonated explosives or ordnance may remain, public safety may also be a major concern. Safety impacts can also be quantified using probabilistic measures of risk. Health and safety concerns include not only the impacts associated with an actual or potential operational release but also those occurring as a result of remediation efforts.

There is no generally accepted set of end points for evaluating environmental risk. Existing methodologies have concentrated on commercial resources that are evaluated for natural resource damage assessments in accordance with several federal statutes (e.g., CERCLA, the Clean Water Act, and the oil pollution control act). National Environmental Policy Act evaluations enumerate populations, espe-

cially populations of endangered species, that might be impacted by an environmental release or by a RCRA investigation and remediation. The ER Program's Ecological Risk Assessment team is developing ecosystem models for the Pajarito Plateau on which additional measures of environmental impacts for the ER Program may be based in the future.

Social and economic concerns include impacts on commercial and potentially developable natural resources, as mentioned above; impacts on the local community, such as the need to absorb large numbers of new, possibly temporary, workers; and public alarm over actual or potential releases of toxic materials to the atmosphere or major aquifers.

Direct impacts on the Laboratory include both operational impacts (such as loss of productivity caused by disruption of normal research and development activities) and penalties for noncompliance with legislative or regulatory directives.

The final category of concerns—costs—includes not only the direct monetary costs of performing RCRA investigations and corrective actions but also other impacts of these activities on ER Program operations, including the program's ability to coordinate resources such as mobile laboratories, analytical laboratories, and personnel.

Methods for decision making to satisfy multiple objectives, especially in the presence of uncertainty both about actual conditions and about the effectiveness of proposed actions, range from the intuitive approaches used in everyday life to formal multiattribute decision analysis described in Appendix I. Given the legal and other ramifications of RCRA process decisions, methods near the formal end of this spectrum may be preferred to less formal approaches. However, the primary RCRA requirement is that the decision process be technically sound and well documented. The technical approach of the ER Program at the Laboratory provides for a range of methods so that the formality of the decision-making process can reflect the complexity of the problem.

4.2.2 Screening Action Levels

SALs are media-specific concentration levels for constituents that can be compared with measurements of concentration levels made during RFI investigations in order to make preliminary or even final decisions about the site. SALs are used

- to prioritize RFI/CMS activities, focusing resources appropriately for timely and cost-effective investigations and corrective actions;
- to identify contaminants of concern should a more thorough risk assessment be required; and
- to indicate PRSs at which constituent concentrations are very unlikely to be of concern from the perspective of human health and the environment and that are therefore appropriate to propose for NFA. In addition, an evaluation of the NFA proposal will incorporate consideration of ALARA guidelines, appropriate regulatory standards, ecological impacts, and the potential for effects from multiple contaminants.

Appendix J provides tables of SALs for some potential chemical and radiological constituents of PRSs at the Laboratory. SALs to be used as above should be conservative. The calculated values are conservative partially because they are based on an assumed land use that involves extensive exposure to contaminants (i.e., residential). Therefore, detection of constituents in concentrations greater than SALs does not necessarily indicate the need for corrective action, only for more site-specific evaluation and possibly further site characterization. For some constituents, there are regulatory standards that significantly exceed the SALs calculated in Appendix J. In other instances, a site-specific baseline risk assessment using more realistic current and future land use assumptions, as discussed in Section 4.3, may indicate that NFA is appropriate.

There are a small number of constituents for which detection limits less than SALs are not technically achievable. The available analytical method with the lowest detection limit will be selected for these constituents, and this detection limit will be used as an SAL.

4.2.2.1 Nonradiological Constituents

The ER Program will derive SALs following the methodology published in proposed Subpart S to RCRA (EPA 1990, 0432). The list of action levels provided in the supporting materials for proposed Subpart S includes a limited number of organic and inorganic constituents but does not address all potential constituents of concern at the Laboratory. The ER Program will use proposed Subpart S methodology to derive SALs for nonradiological hazardous constituents detected in initial characterization efforts.

The following principles, as given in proposed Subpart S, are used to develop SALs for the RFI:

- SALs must be determined in a manner consistent with the principles and procedures set forth in EPA guidelines for assessing the health risks of environmental pollutants.

- Toxicology studies must be scientifically valid and must be conducted in accordance with the good-laboratory-practice standards set forth in 40 CFR 272 (EPA 1989, 0433). Because the verification of these requirements is labor-intensive, SALs will be based, when possible, on toxicity values available from the most recent version of EPA's Integrated Risk Information System (IRIS) data base (EPA 1992, 0830) or on EPA's health effects assessment summary tables (HEAST) document (EPA 1991, 0658). These values have undergone extensive scientific scrutiny. When IRIS or HEAST does not provide toxicity values for a constituent, other toxicological data may be used. In particular, derivation of toxicity values may be necessary for certain chemical mixtures (e.g., high explosives) that are likely to be present in some media at the Laboratory.

- For Class A and B (known and probable, respectively) nonradiological carcinogens, SALs must be consistent with a 10^{-6} upper-bound excess cancer risk. For Class C (possible) carcinogens, SALs must be consistent with a 10^{-5} upper-bound excess cancer risk.

- Concentrations of systemic toxicants should be set so that a human population could be exposed on a daily basis without appreciable risk of adverse health effects over a lifetime. This method of evaluation uses "reference doses" as toxicity values; these values are concentrations below which adverse effects have not been observed and which incorporate uncertainty factors.

- Applicable federal and state regulatory standards (e.g., those for maximum contaminant levels in drinking water) will be used as SALs when they are lower than those derived using Subpart S methodology.

At Los Alamos, SALs are needed primarily for soil materials. Analogous SALs will be used for other environmental media (e.g., groundwater, surface water, and air), as necessary. Because the EPA has not recommended special criteria for sediments or for saturated soils that are not part of an aquifer, the Laboratory will use the same SALs for these media as for soils. Additional evaluation methods may be needed for substances that involve unique exposure considerations (e.g., structural debris, shrapnel, high explosives, asbestos, asphalt); these evaluation methods are discussed in Appendix J.

SALs for soil, groundwater, surface water, and air will be based on the default exposure assumptions recommended in Subpart S (EPA 1990, 0432). In general, the receptor is assumed to be a long-term (i.e., 70-yr) resident at the PRS and is assumed to be present 365 days/yr, drink 2 L of water per day, and inhale 20 m^3 of air per day. Following Subpart S guidance, soil ingestion scenarios assume that the receptor is a child who ingests 200 mg/day of soil (for systemic toxicants) or an adult who ingests 100 mg/day of soil (for carcinogenic constituents).

SALs for soils are applicable to surface soils (e.g., the upper 2 ft of earth) and also to near-surface soils (e.g., the upper 12 ft of earth) for locations where excavation for housing or commercial/industrial development could bring subsurface soils to the surface. These soil depths are specified in EPA's interim final RFI guidance (EPA 1989, 0088). For mesa top areas, where the soil that overlies the tuff or basalt is sometimes only a few inches deep, constituent levels are evaluated for soils down to the depth at which consolidated materials are located.

When volatile constituents are present in soils or tuff, exposure via inhalation is also possible. Evaluation of this exposure route for soil constituents with significant volatilization potential is accomplished using an EPA methodology (EPA 1991, 0302) and appropriate residential exposure assumptions (Appendix J).

If constituents are detected above background levels in unsaturated deep soils, for which the direct exposure scenarios underlying the definition of SALs for surface soils are inappropriate, the RFI assesses whether these constituents might migrate to an aquifer in concentrations exceeding the SALs for groundwater. Determination that such a potential exists could trigger a CMS.

SALs for groundwater apply only to aquifers. As defined in 40 CFR 260.10, an aquifer is a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs. SALs for groundwater will be calculated as shown in Appendix J. If regulatory standards (e.g., maximum contaminant levels specified in the Safe Drinking Water Act, 40 CFR 141.11;141.61) exist that are lower than calculated values, these lower values will be used as SALs.

With the exception of one or two OUs, data on hazardous constituent levels in groundwater will not be collected for initial characterization of individual PRSs. If subsurface data for any PRS indicate that contamination caused by Laboratory operations may have migrated to the depth of the main aquifer (i.e., several hundred to 1,000 ft), groundwater data from that PRS will be obtained and compared with SALs. Additionally, if perched water capable of yielding sufficient water to maintain a well is identified, constituent concentrations in the perched aquifer will be compared with SALs.

The regulations that implement the Clean Water Act (40 CFR 122.2) define surface waters, or "waters of the United States," as lakes, rivers, streams (including intermittent and ephemeral streams) and other surface water bodies (and their tributaries) that could be used for recreational purposes, fishing, or industrial purposes. Perennial surface water features at or near the Laboratory include Ashley Pond in TA-1 and the upper reaches of streams in the canyons. The lower reaches of most canyon streams in the Los Alamos area become intermittent or ephemeral surface water features as they near the Rio Grande. SALs for surface waters will be applied to Ashley Pond and canyon stream water and will be the same criteria as those used for groundwater (as discussed above and in Appendix J). This approach is consistent with proposed Subpart S guidance.

The derivation of SALs for air is described in Appendix J. Currently, there are no known operative emission sources (e.g., stacks) at the PRSs to be evaluated under the ER Program. However, if needed, SALs for air will be applied at the point of closest public access to the PRS under investigation. Exposure to volatile contaminants in soils will be evaluated using soil screening criteria (as discussed above and in Appendix J).

4.2.2.2 Radiological Constituents

Radiological materials (except mixed wastes) are not regulated by RCRA and are not subject to the provisions of the HSWA Module; therefore, the action levels in proposed Subpart S do not address radioactive constituents. However, to allow consideration of all relevant and applicable standards for the protection of human health and the environment, as is consistent with DOE orders stipulating that corrective actions meet the requirements of CERCLA, the ER Program will address radiological as well as nonradiological constituents. Thus, screening criteria are needed for radiological constituents. Together with the SALs for nonradiological constituent levels, the SALs for the radiological constituents will permit prioritizing sites needing characterization and subsequent remedial actions.

Considerations that influence the development of SALs for radiological constituents include the following:

- Most current radiation protection standards (e.g., 40 CFR 190; 40 CFR 141.16; DOE Orders 5400.5 and 5480.14;10 CFR 61; and 10 CFR 20) are based on dose limits rather than on concentration limits in environmental media. Many of these radiation dose limits apply to cumulative exposures from all radioactive constituents present and may apply to a specific exposure pathway or multiple pathways.

- Radiation dose to humans from background radiation [approximately 327 mrem/yr (LANL 1992, 0740)] is much higher

than limits established in radiation protection standards for the public.

- The generally accepted radiation dose limit for the individual in the general public who receives the maximum exposure is 100 mrem/yr over background (DOE 1990, 0080; ICRP 1991, 0777; NCRP 1988, 0778; and 10 CFR 20). Radiation dose to the public is further limited to 25 mrem/yr from individual facilities or sources [e.g., 40 CFR 190-192; DOE Order 5820.2A (DOE 1988, 0074); and 10 CFR 61]. These are cumulative limits for all radioactive constituents and pathways, and lower limits must be used when considering individual pathways or radionuclides. Thus, it seems appropriate to set the dose limit for individual radionuclides at a fraction of the 100-mrem/yr and 25-mrem/yr limits in order to derive appropriate SALs for a single constituent at a PRS.

- In addition to dose-based criteria, DOE Order 5400.5 contains a requirement to adhere to the ALARA principle to maintain all radiation exposures to levels as low as reasonably achievable (DOE 1990, 0080).

- SALs must also be high enough to allow discrimination between areas of manmade contamination and uncontaminated areas. Limitations of current instruments for discriminating between background and above-background levels of ionizing radiation must be considered.

In view of the above considerations, an annual dose limit of 10 mrem/yr (incremental above background and cumulative over all exposure routes) is proposed here as the basis for deriving SALs for the radioactive constituents in soils. The rationale for this proposed dose limit is as follows:

- The proposed dose limit of 10 mrem/yr is a fraction of the current regulatory standards of 100 mrem/yr and 25 mrem/yr above background.

- The dose limit of 10 mrem/yr is specified in DOE Order 5400.5 as a reporting level for doses to the general public resulting from activities conducted under DOE programs.

- The recommended dose limit is compatible with the direct detection limit (about 1 μR/hr) for current instruments designed to detect gamma radiation in the field.

- A lower dose value may not be discernible from the background radiation value, which averages about 327 mrem/yr (including radon exposure) (Environmental Protection Group 1992, 0740). The 10 mrem/yr dose limit represents an incremental dose of only 3% of the natural background dose.

Screening levels for radionuclides based on the proposed dose limit can be derived using the RESRAD code (Gilbert et al. 1989, 0754), which has been developed by DOE for use in developing guidelines for residual radioactive material. Use of RESRAD methodology for developing guidelines is specified under DOE Order

5400.5. As for nonradiological constituents, SALs for radionuclides will be derived based on the assumption of residential land use in order to derive the most conservative (i.e., lowest) SALs. Environmental parameter values (e.g., soil properties, rainfall) required by the code are set appropriately for the Pajarito Plateau.

RESRAD can be used to model exposure to multiple radionuclides from multiple environmental media and pathways, including soil, air, surface water, groundwater, and food products. Potential exposure routes include direct external exposure, inhalation (particulates and radon), and ingestion (soil, water, and food products). In order to derive media-specific SALs, RESRAD is used for single radionuclides and individual environmental media. Existing regulatory standards for certain radionuclides [such as 4 mrem/yr for manmade beta-gamma emitters in drinking water (40 CFR 141.16)] will be used as SALs when they are more conservative than RESRAD-derived limits. (Drinking water is not currently considered a plausible exposure pathway for Laboratory contaminants because the main aquifer is located from several hundred feet to greater than 1,000 ft below the land surface, and contaminants from Laboratory operations have not been detected in the aquifer. However, groundwater monitoring will continue to verify that contamination has not occurred, and SALs will be derived for groundwater, as needed.)

If all radiological constituents in a PRS are determined to be below SALs, the DOE nonetheless requires that a further evaluation be conducted to determine that levels are as low as reasonably achievable (DOE 1990, 0080). If social, technical, economic, and public policy considerations indicate that lower levels are achievable, remediation may be required.

4.2.3 Cleanup Criteria

SALs are not cleanup criteria; they are generally used only to identify contaminants of concern and to guide further sampling efforts. Because they are conservative, their use as target levels for the purposes of site cleanup might be unnecessarily restrictive and often impracticable as well. Development of appropriate criteria is one of the tasks of the CMS for each site (Section 3.5.2), and media cleanup standards will be included in the RCRA permit modification that initiates the CMI (Section 3.5.2). There are also many legislative cleanup standards, such as those provided for polychlorinated biphenyls (PCBs) to implement the Toxic Substances Control Act (40 CFR 761), that may be applied, especially for VCAs.

Methodologies for establishing target cleanup levels have been recommended by EPA in CERCLA risk assessment guidance documents (EPA 1991, 0302). For nonradiological constituents, the CMS target cleanup levels are generally established within the protective risk range of 10^{-4} to 10^{-6}, as specified under proposed Subpart S guidance for CMS evaluations (EPA 1990, 0432). Standards have been established only for radium and thorium (40 CFR 192)]; therefore, they will need to be derived for other radiological contaminants of concern.

In addition to the protection of human health and the environment, a number of other factors need to be considered in selecting a remedy. Factors mentioned in the National Contingency Plan (40 CFR 300, EPA 1990, 0559) include reduction of toxicity, mobility, and volume of wastes; short-term effectiveness; compliance with regulatory requirements; long-term effectiveness; implementability; public acceptance; and cost.

4.3 Approach to Programmatic Human-Health-Based Risk Assessment

4.3.1 Background

To meet the requirements of RCRA and CERCLA, the RFIs at the Laboratory address the potential risks to human health associated with contaminants at, or released from, PRSs. The nature, level, and extent of contamination at PRSs are determined through the site characterization process. The ER Program has adopted a phased approach to site characterization and evaluation of potential health risk (Section 4.1 and Figure 4-1). In this approach, baseline risk assessment may be needed following the identification of some contaminants of concern or following determination that corrective action may be needed based on ALARA guidelines, ecological risks, or other considerations.

EPA has not published detailed risk assessment guidance for sites regulated under RCRA. The ER Program's approach to risk assessment generally follows the methods EPA has recommended for CERCLA sites (EPA 1989, 0305; EPA 1991, 0302; EPA 1991, 0831). However, some modifications to that approach will be made in the Laboratory's ER Program. In particular, a comparison of contaminant levels at a PRS with SALs will be substituted for the CERCLA procedure for identifying contaminants of concern (EPA 1990, 0432).

The major elements of baseline risk assessments to be conducted for the Laboratory's ER Program are

- identification of contaminants of concern by means of the screening process described in Section 4.2.2;
- exposure assessment, the identification of appropriate land use scenarios, and environmental migration pathways and receptors, and estimation of contaminant migration and intake parameters in order to translate concentrations of contaminants in environmental media into chemical intake and radiological dose levels for human receptors;
- toxicity assessment, the identification of significant toxic effects and routes of toxicity of contaminants of concern, and quantification of these effects; and
- risk characterization, the estimation of noncarcinogenic toxic impacts, and excess cancer risks as a function of intake or dose.

These four steps can be applied to characterize the cumulative risk associated with multiple PRSs in an operable unit (OU) or across the Laboratory, as well as the impact of a single PRS.

For PRSs containing constituents in excess of SALs, baseline risk assessments will be conducted following Phase I if sufficient data are available. In some cases, collecting additional data may be necessary to perform an adequate baseline risk assessment.

When a risk assessment is performed to support the CMS, the risks associated with each proposed remediation alternative will be analyzed. This assessment will address both long-term risks remaining after implementation of a proposed remedial alternative and short-term risks to workers and the public of implementing the proposed alternatives.

A risk assessment methodology is being developed to (1) establish the scope of baseline risk assessments, (2) establish the scope of the CMS risk assessments, and (3) establish a consistent approach to risk assessment for all OUs. This methodology is described in Appendix K, which specifies the contents of the OU-specific baseline risk assessments to be prepared during the RFI and the risk assessment for corrective measures alternatives to be prepared as part of the CMS.

In the following sections, the components of baseline risk assessments outlined above and of risk assessment for the CMS process are described in greater detail.

4.3.2 Identification of Contaminants of Concern

PRS constituents measured at levels above SALs and/or regulatory concentration criteria will be considered contaminants of concern to be evaluated in PRS-specific baseline risk assessments and CMS risk assessments. In addition, as noted in Section 4.1.4, some constituents may be identified as contaminants of concern even when below their SALs in cases where more than one hazardous constituent is present. Exposure assessment and risk assessment, as described in CERCLA guidance (EPA 1989, 0305), will be conducted for these contaminants only.

4.3.3 Conceptual Models for Exposure Assessment

Conceptual exposure models are used to describe the source or sources of contamination, the movement of contaminants through the environment, and the exposure of human receptors. These models will be used to help identify appropriate media and locations for sampling. The data will be used to estimate model parameters so that radiological doses and chemical intake by receptors can be estimated with site-specific information.

Contaminant sources can be categorized as primary (e.g., the PRS itself) or secondary (e.g., soil contaminated by a release from the PRS). Examples of primary sources at the Laboratory are septic tanks, drainlines, buried structures and wastes, solid wastes and structural debris on canyon walls, landfills, and firing sites.

Potential mechanisms by which contamination may be released from a source to the environment include leakage, infiltration, leaching, re-entrainment of contaminated particulate matter by wind or surface run-off, particulate settling, erosion, human and animal intrusion, and evapotranspiration. Possible environmental migration pathways include air, surface water, the vadose zone, groundwater, plants and animals, and direct contact with soil or structural surfaces. Laboratory studies support the current assessment that extensive liquid-phase migration in the vadose zone is highly unlikely in the Bandelier Tuff because the tuff is extremely dry and infiltration of natural precipitation cannot provide the quantities of water necessary to sustain movement of contaminants downward (Purtymun and Stoker 1988, 0205). However, vapor phase migration is possible in the vadose zone.

Potential contact media are soil, groundwater, surface water, air, and the surfaces of structures or debris. Groundwater in the regional aquifer is not currently considered a potential contact medium because of the great depth to the water table and limited transport in the vadose zone. However, it is possible that in the future perched water could serve as a source of domestic water. Exposure may occur as a result of inhaling, ingesting, or coming in direct contact with these contaminated media.

Exposure to external radiation is a special type of exposure because transport of contaminants through environmental media is not necessary for the receptor to receive a dose. However, dose decreases exponentially with increasing distance from the source.

Assumptions about current and future land uses are important in identifying the receptors to be used in baseline risk assessments. Current PRS land uses include residential, recreational, and commercial or industrial use. A few PRSs located in the town of Los Alamos are classified as residential. A few other PRSs that are neither located on Laboratory property nor used residentially are categorized as recreational land use. In general, land use of the OUs located on Laboratory property is considered commercial/industrial, although recreational use of a few unfenced sites may occur. However, many of the technical areas are fenced and most are under some form of institutional control (i.e., access is restricted).

It is assumed that future use of all PRSs not currently located on Laboratory property may be residential. For most PRSs located on Laboratory property, continued commercial/industrial use and eventual release of these lands for recreational use (e.g., camping) is assumed. The use of such assumptions for risk assessment is supported by proposed Subpart S, which states that

> "contaminated soil would be remediated to levels consistent with plausible future patterns of use... . At industrial sites or sites dedicated to long-term hazardous waste management, cleanup to less stringent levels (than residential cleanup levels) might be appropriate, although institutional controls could be necessary to ensure that the use pattern did not change" (EPA 1990, 0432).

If Laboratory property is released for recreational use in the future, risk assessment based on these assumptions will remain appropriate. However, limited areas that might be used residentially (e.g., for ranger housing) should be re-evaluated at the time of transfer, using assumptions for a residential exposure scenario.

The Laboratory plans long-term hazardous waste management for some of the material disposal areas (MDAs) and possibly for a small number of additional PRSs. For baseline risk assessments, it is assumed that these sites will be under institutional control for 100 years or more. At MDAs in which buried transuranic waste contains concentrations greater than 100 nCi/g, a longer period of institutional control may be assumed. Risk assessment for appropriate exposure scenarios (e.g., exposure of trespassers) will be conducted for these areas.

Current occupational exposures to Laboratory workers are evaluated by the operating groups of various facilities or by the Health Physics Operations (HS-1), Safety and Risk Assessment (HS-3), and Industrial Hygiene (HS-5) groups in compliance with Occupational Health and Safety Act requirements and with DOE Order 5480.11 (DOE 1988, 0076). Risk assessment for future commercial/industrial use scenarios

will evaluate non-Laboratory workers as the primary receptor at these PRSs. Standard default exposure parameters for commercial/ industrial receptors will be used for these assessments.

4.3.4 Toxicity Assessment

Two types of toxicity will be considered: systemic toxicity and carcinogenic effects. Methods for estimating the carcinogenic effects of non-radiological contaminants differ from those to be used for radiological contaminants.

Systemic toxicity and carcinogenic risk for non-radiological contaminants of concern will be evaluated using toxicity values (if available) obtained from the most recent versions of EPA's IRIS data base and HEAST document. Other toxicity values may be derived based on data from the literature if values are not available from IRIS or HEAST. The hazard index (Appendix J) provides a measure of systemic toxicity. Excess cancer risks will be estimated for potential carcinogens.

Exposure to radiological contaminants of concern will be evaluated initially by estimating annual doses for the appropriate potential receptors using the RESRAD code. These dose estimates will be converted to carcinogenic risk estimates using data from EPA (1989, 0781) and the National Research Council (BEIR 1988, 0030).

Other potential toxicological effects of radiation exposure include genetic and reproductive effects. However, the risk that these effects will occur is generally much lower than the risk of cancer induction. Therefore, the EPA considers that carcinogenic risk assessment is sufficient evaluation of toxic effects for radionuclides (EPA 1989, 0305).

4.3.5 Risk Characterization

The exposure model and the toxicological model are used together to estimate the risk of systemic toxicity and carcinogenic effects associated with one or several PRSs impacting the same receptor. Risk estimates for nonradiological contaminants of concern will be compared with the acceptable risk range designated by EPA for exposure to the general public (target risk range). This risk range is 10^{-4} to 10^{-6} excess upper-bound lifetime cancer risk to an individual (EPA 1990, 0432) for carcinogens. For systemic toxicity, exposure levels will be evaluated by comparison with an acceptable hazard index equal to one. For radiological contaminants of concern, estimated doses, will be compared with the target dose limit of 10 mrem/yr.

Cumulative impacts across PRSs in an OU will be evaluated in OU-specific baseline risk assessments. The need for a separate risk assessment addressing cumulative health effects from multiple OUs is evaluated in Appendix K.

4.3.6 Risk Assessment for Corrective Actions

The CMS risk evaluations will generally follow the methodology used for baseline risk assessment. The risks for each alternative will be evaluated to determine how well the alternatives meet requirements for overall protection of human health and the environment. CMS assessments will generally focus on the long-term effectiveness of the corrective measure alternatives by evaluating the residual risks present after

remediation. Short-term risks associated with the alternatives will also be evaluated, including risks to workers implementing the proposed alternatives.

Following CMI or VCA, a final risk assessment may be performed to provide another measure (in addition to or instead of direct comparison with target cleanup levels) of the effectiveness of the implemented remedy. These evaluations will also follow the methodology used for baseline risk assessment but will incorporate data collected during the corrective action or by a longer-term monitoring program.

4.4 Field Investigations

Field work associated with remedial investigations consists of measurements, sample collection, and sample analysis designed to characterize environmental conditions and contaminant concentrations and distributions in environmental media. The work relies on standardized scientific and engineering methodologies, much of which is (or will be) described in standard operating procedures (SOPs). In addition, all field work is governed by rigidly enforced health and safety and quality assurance procedures. Some of the proposed field work involves significant hazards, which must be fully mitigated to ensure personnel safety. Quality assurance activities are a cornerstone of all field work to ensure that all collected data are accurate, representative, and defensible.

4.4.1 Field and Engineering Surveys

Before environmental samples are collected, field surveys will be conducted. These surveys may consist of observing environmental conditions, such as stream channel characteristics, geologic or soils mapping, selecting and marking the physical location of sampling points, and establishing appropriate methods for collecting samples (such as determining the feasibility of vehicle access to certain locations).

Engineering surveys will be conducted to predetermine sampling points, such as those around the perimeter of an MDA. The locations of all underground utilities in the area to be sampled will be marked to avoid disrupting those utilities. When hazardous materials exist at a site in quantities sufficient to necessitate the use of protective clothing and decontamination of equipment, control zones will be identified and marked.

4.4.2 Geophysical Surveys

Better definition of subsurface conditions will often be necessary to locate subsurface sampling points correctly and safely. Geophysical techniques such as magnetometry, electromagnetic surveys, ground-penetrating radar, and seismic methods can be used to define the location of buried objects, to establish the boundaries of burial pits, and to investigate subsurface conditions such as the depth to a saturated zone and the depth of bedrock. Because these methods are nonintrusive and are readily applied to large areas, they are very cost-effective in reducing uncertainties associated with subsurface sampling.

4.4.3 Surface and Near-Surface Sampling

Samples of soil and sediment within a foot or two of the surface and samples of liquids and sludge from tanks and impoundments are collected by hand methods involving a variety of sampling tools such as scoops, hand augers, and thin-wall samplers. Such samples may also be collected from the walls or bottom of an excavation such as that resulting from removal of an underground storage tank. Samples of the contents of drums and other containers may also be collected to characterize their contents.

4.4.4 Borehole Sampling and Monitor Well Construction

Collection of soil and sediment samples below a few feet in depth is best accomplished using power borehole or well-drilling equipment. For sample depths up to 100 to 150 ft, rotary augers are commonly used to drill boreholes and to collect interval or continuous cores of the material penetrated. In some instances, these boreholes may be equipped with instrumentation to measure soil properties, including soil density and water content.

When groundwater investigations are required at shallow depths, as in the case of perched alluvial groundwater bodies, monitoring wells can be drilled using solid or hollow-stem augers. For depths below about 100 ft, which are typically involved in investigations in the main aquifer underlying Los Alamos, other drilling methods, such as cable tool, rotary, and reverse rotary, will be used. Each of these methods has advantages and disadvantages with respect to representativeness of collected samples, cost effectiveness, and suitability of the completed well.

Completed monitoring wells are used for groundwater sampling to measure fluctuations in water levels and to perform aquifer tests that measure hydrogeologic properties.

4.4.5 Field Screening

For sites with potential radioactive contamination, a variety of radiological field screening instruments are used for quantitative measurements of alpha, beta, and gamma radiation. These measurements may involve both in-situ measurements of soil, sediment, equipment, and structures and collection of samples to be screened in a mobile laboratory. Such screening may be done to stratify or bias the selection of samples for laboratory analysis or to guide the extent of cleanup during implementation of corrective measures. Field instruments are also used to monitor for the presence of volatile organic compounds such as benzene and tri-choloroethane, generally for the purpose of ensuring proper personnel protection but also to guide decisions on sampling locations and the types of analysis to be requested.

Other field screening is performed using specially designed test kits that provide data on contaminants such as PCBs, petroleum hydrocarbons, or high explosives.

4.4.6 Mobile Laboratories

Two mobile laboratories have been developed for use at Los Alamos. One laboratory has an x-ray fluorescence spectrometer, a gas chromatograph, and a gas chromatograph/mass spectrometer. These instruments can determine metal concentrations for elements with atomic numbers greater than 10 and concentrations of organic contaminants, including volatile and semivolatile hazardous constituents. The second laboratory is instrumented to perform radiological analyses, using both solid-state detectors and a liquid scintillation detector. Additional field laboratories and field laboratory methods are being developed.

The investigator uses data from both laboratories to

- screen samples so that appropriate decisions can be made about assigning and transporting samples to offsite analytical laboratories,
- provide fast analyses so that any need for additional sampling can be determined while the sampling crews are still in the field, and
- to decide when drilling can be halted after a drill core passes through a contaminated subsurface zone.

4.4.7 Geotechnical Analysis

Some investigations will require quantitative measurements of the geotechnical properties of soil or rock, including such properties as bulk density, porosity, permeability, and cation exchange capacity. Samples may be collected by a number of methods and taken to specially equipped laboratories to be measured for the required parameters. The data from these measurements are used in transport calculations during baseline risk assessments.

4.4.8 Geochemistry

Characterizing the geochemical properties of rocks and soils is important for evaluating potential contaminant transport. The results can also be used in subsurface mapping of geologic units. The mineralogy of a sample can be established by a variety of techniques, including thin-section examination, X-ray diffraction, use of electron microprobes, and chemical separations.

4.4.9 Field Data and Sample Analyses

Many types of data will be obtained during RFIs. Field surveys use portable instruments to make in-situ measurements with minimal disturbance of the environment (e.g., geophysical measurements and radiological surveys). A number of field test methods are used to screen samples near the point of collection (e.g., field tests for high explosives and PCBs). Field laboratories provide an increasing range of onsite analytical services. Complete analytical services with well-documented quality assurance are provided through the ER Program's Sample Coordination Facility.

Reported measurements are of several types:

- categorical or nominal measurements (e.g., lithologic logs, geomorphologic maps);
- ordinal measurements (e.g., presence or absence of organic vapors; positive, possible, or no signal from a magnetic survey); and
- ratio or interval measurements (e.g., chemical concentration data, radioactive count data, land survey measurements). Measurements of this type may further be classified by their accuracy and precision, which depend both on the specific technology used and on the level of quality assurance and quality control used.

Measurements of any type may be analyte-specific (e.g., concentrations of specific constituents in a sample or presence of a specific type of high explosive). Others measure presence or concentration of a group of constituents (e.g., organic vapors, gamma emitters). Finally, in addition to measurements of concentrations, there are measurements of other site characteristics, such as soil types and hydrogeologic parameters.

The analytical levels discussed by EPA (1987, 0086) provide another method for classifying data:

- Analytical Level 1 measurements are either categorical or presence/ absence field measurements.
- Analytical Level 2 includes other ordinal measurements, some non-analyte-specific ratio measurements (such as gross alpha counting), and procedures for tentatively identifying specific constituents.
- Analytical Levels 3 and 4 measurements are analyte-specific ratio measurements. Analytical Level 4 measurements are obtained following a set of EPA's analytical protocols and procedures for sample handling, tracking, and quality assurance. (Laboratories in the Contract Laboratory Program use these procedures, and other laboratories may also follow them to provide data of comparable quality.) Measurements at Analytical Level 3 may be equivalent to those at Level 4 in terms of detection levels, accuracy, and precision; however, they are not made following the complete EPA protocols.
- Finally, Analytical Level 5 includes novel methods, modifications of standard techniques, and applications of standard procedures when detection limits or other parameters may be inferior to their nominal values. Although measurements made at Analytical Level 5 are also analyte-specific ratio measurements, their precision and accuracy may be more variable than those at Levels 3 or 4.

Table 4-3 in EPA's DQO process development document (EPA 1987, 0086) makes recommendations about the analytical levels appropriate for various applications,

e.g., for site characterization, risk assessment, verification of site cleanup, and monitoring. In addition, methods for supplementing more accurate and reliable data with data from lower analytical levels can be used at all levels of decision making. Field surveys and rapid-turnaround field laboratory results are useful in selecting samples for laboratory analysis, either as a basis for selecting a biased sample (when the investigator is interested in bounding the level or extent of contamination at a site) or for stratifying the sample to improve estimation of the average contamination. If field results are moderately well correlated with more accurate laboratory analyses, regression can be used to improve estimates of the average contamination or of its distribution over the site. The statistical bases for some of these methods, such as sample stratification and double sampling, are reviewed in Appendix H.

4.5 Technical Considerations for the Selection of an Appropriate Response Action

As shown in Figure 4-1, the RCRA process may terminate at a number of points:

- after review and evaluation of archival information, without additional field investigations;
- after a screening assessment and review of the need for corrective action based on the results of Phase I of the RFI;
- after baseline risk assessment; or
- after the design and implementation of corrective actions.

There are a number of possible end points: NFA, further investigation and/or corrective action deferred until the site is decommissioned, VCA, conditional remediation, and final remediation.

4.5.1 No Further Action

A decision as to whether corrective action is required for a site is the principal decision made during the RFI. It may be made at any of the three RFI termination points listed above: following the evaluation of archival information, after Phase I investigation of the site, or after a baseline risk assessment. A decision to propose NFA during the RFI implies that neither additional investigation nor corrective action is necessary.

A strategy for selecting and defending a proposal for NFA on the basis of archival information only is outlined in Appendix I. Such a proposal requires a review of archival information not only to ascertain that there are no health and safety risks associated with the site but also to evaluate many of the other factors discussed in Section 4.2.1, particularly environmental risks, compliance with regulatory requirements, public concerns, and impacts on Laboratory operations. For some sites, it may be possible to complete a screening assessment (Section 4.1.4) using historical data.

For many PRSs at Los Alamos, existing nonquantitative information strongly suggests that no environmental release has occurred. Sampling to provide quan-

titative data for a screening assessment should provide enough information to complete a proposal for NFA in these cases.

The third point at which NFA might be proposed is following baseline risk assessment when this assessment shows that, although contamination is present and potential exposure pathways exist, the associated risks are nevertheless below levels of concern. Once again, before proposing NFA under these conditions, the other evaluation factors discussed in Section 4.2.1 must be reviewed.

4.5.2 Deferred Action

Deferred action, like NFA, may be proposed at any of the RFI termination points. It may be appropriate for currently active sites or for other, inactive PRSs that are located in currently active sites. The proposal may be accompanied by plans for a limited site investigation, such as reconnaissance sampling or perimeter monitoring. Otherwise, strategies for selecting and defending this alternative are quite similar to those described in Section 4.5.1. In evaluating health and environmental risks, it is primarily the current risks that are of concern, because only postponement—not cancellation of investigation and/or corrective action—is proposed.

4.5.3 Conditional Remedies

Conditional remedies, generally combining a prompt corrective measure to reduce risk, together with an ongoing schedule for site monitoring, may be proposed for sites where total cleanup is impractical or delaying implementation of the final remedy is in the interest of the environment (Section 3.5.1.2.2). In particular, site stabilization using appropriate containment technologies (Section 4.5.4.1) will be implemented as a conditional remedy at some of the large MDAs. Site monitoring is a second technological component of any conditional remedy. Continued institutional control to control public access, to track Laboratory activities in the area, and to prevent further degradation of the environment is a required administrative component.

4.5.4 Corrective Measures

If corrective action is necessary or deferred, an appropriate corrective measure is generally selected following a CMS. When an obvious and effective alternative exists, it may be proposed as a VCA without a formal CMS, either immediately after the evaluation of archival information or else after a limited RFI Phase I investigation. VCAs tend to be removal and treatment options rather than in-situ treatment or containment and therefore must meet restrictions on treatment and disposal of hazardous wastes and other restrictions that apply to alternatives of this type. If there are significant questions about the ability of the proposed option to meet these criteria, then CMS and CMI are more appropriate than VCA.

The following brief descriptions of available remedial technologies are adapted from an EPA manual (EPA 1990, 0791). The discussion is not intended to be exhaustive but covers those technologies most likely to be useful for the Laboratory's ER Program. New and innovative technologies are continually being developed, as are methods to adapt established technologies to the specialized needs and conditions of the Laboratory.

4.5.4.1 Containment Technologies

Capping is the process of covering contaminated materials to prevent direct contact with receptors, to control the infiltration of surface water and precipitation, and to control the release of soil vapors. Various cap designs and capping materials are available, including

- soil caps consisting of a compacted layer of local soil and a layer of topsoil;
- hard caps made of asphaltic concrete or Portland cement concrete; and
- multilayered caps designed to meet RCRA standards, typically consisting of an upper vegetative (topsoil) layer, a drainage layer, and a low-permeability layer.

The Laboratory is conducting pilot studies to determine combinations of capping features that are most appropriate for the climatological conditions of the Pajarito Plateau (Appendix D).

Surface water control measures, including grading and terracing; ditches and channels; and structures such as berms, dikes, and flood walls are used to control surface drainage on, around, and through an area. Surface run-off occurs over most of the Pajarito Plateau during severe storm events and rapid snow melt, and thus some form of surface water control may be required at Laboratory sites with contaminated soils.

4.5.4.2 Removal Technologies

Although excavation of earth materials and dredging in sediments are standard construction practices, their application to the removal of hazardous wastes entails some special technical considerations:

- The work can be extremely hazardous, and extensive safety procedures and monitoring may be required to ensure the protection of the workers and the public and to prevent collateral damage to the environment.
- Special equipment, adapted to minimize disturbance of the deposit and secondary migration, may be required.
- Areas containing drums, buried tanks, or similar obstructions may require significant amounts of hand and small-machine work.
- Selective removal of wastes to ensure the segregation of incompatible wastes and of wastes requiring different disposal and treatment methods may be required.
- Removed sediments must be dewatered, and the removed water must be treated for possible contamination.

Pumpable liquids and sludges can be removed from pits, ponds, lagoons, sumps, trenches and tanks to prevent the contamination of adjacent soils and aquifers. The waste must be categorized by phase (e.g., organic, aqueous, and heavy sludge phases) to determine the appropriate removal method(s).

Standard gas collection and migration control systems for landfills are very effective in controlling emissions from municipal and similar landfills, whose gases are typically about half methane and half carbon dioxide, with small amounts of other gases. These systems consist of a combination of monitoring wells, negatively pressured perimeter control, and interior collection and recovery systems. These technologies may be useful at a limited number of Laboratory sites.

4.5.4.3 Treatment Technologies

Incineration, onsite or offsite, is a well-proven method of treating waste streams containing organics, which routinely obtains destruction and removal efficiencies in excess of 99.99% for most organics and PCBs. Incineration is also used to reduce wastes to the minimum feasible volume and to reduce liquid wastes and sludges to residual solids. Wastes and air are introduced into a rotary kiln and are ignited either by an ignition source or by heating the combustibles to autoignition temperature. The gases that evolve from combustion must be further treated in an afterburner or secondary combustion chamber, then fed through a pollution control train to remove particulates and acid gases before being released to the atmosphere. Solid residues from the kiln and pollution control train must be collected and disposed separately. Potential barriers to applying this technology at the Laboratory are community resistance to the construction of an onsite incinerator and the distances to offsite incinerators that meet RCRA requirements.

In-situ biodegradation is a rapidly emerging technology that has been used very successfully to clean up aquifers contaminated with gasoline and other fuel hydrocarbons and is potentially applicable to any biodegradable organic compound. The Laboratory is conducting studies of in-situ biodegradation of high explosives (Unkefer 1992, 0822). The methods most commonly involve stimulating the activity of native microorganisms by introducing oxygen and inorganic nutrients. Microbial actions that may be involved include degrading organic contaminants to carbon dioxide and water (or at least to more soluble by-products), emulsifying adsorbed contaminants, and producing natural, complex organic compounds. These activities result in a net removal of contaminants adsorbed to subsurface soil particles and reduction in the toxicity of remaining organic matter. Because there are many site-specific factors that control the effectiveness and cost of in-situ biodegradation, bench- and pilot-scale studies are necessary. This is particularly true for the arid soils of the Pajarito Plateau.

In-situ solidification/stabilization refers to processes that can be implemented in place to improve the physical characteristics of waste by rendering wastes nonhazardous and nonleachable. Stabilization/solidification reagents are incorporated in the wastes either by pneumatic injection (for nonviscous liquids, fluids, and sludges) or by backhoe mixing (for viscous fluids, solids, and contaminated soil). These technologies are well established for treating inorganic wastes, less so for organic wastes.

Solidification techniques that depend on a reaction between lime and fine siliceous materials in the presence of water are most effective for wastes that have relatively high moisture content (e.g., sludges) and high levels of toxic metals, and that

possibly include some miscellaneous materials such as asbestos, sulfides, and solid plastics but typically not more than 10% to 20% of organic constituents. Solidification processes limit solubility, detoxify the waste contaminants, and produce a monolithic block with some structural integrity; however, the product is still a hazardous waste unless it is delisted.

Soil slurry bioreactor systems can be used to remediate excavated sludges and soils containing organic contaminants. These hybrid systems use aerobic microbial action to degrade or detoxify the contaminants in a slurry reactor (a suspension of soil in water). Both pretreating the wastes, using such pretreatment methods as separating coarser materials and particle scrubbing, and posttreating the slurry and off-gases are generally necessary. Emerging variations of the technology include inoculating the system with special strains of bacteria and adding organic cometabolites to enhance biodegradation of compounds that are difficult to degrade.

Soil vapor extraction is used when volatile organic compounds (VOCs) are the primary contaminants. At Los Alamos, a vapor extraction system is being developed for Area L, where the environmental medium is not soil but tuff. Soil vapor extraction is conventionally performed using a network of wells with perforated well screens packed with gravel, which are connected to a vacuum extraction unit through a surface collection manifold. The vacuum not only draws vapors from the unsaturated zone but also, by decreasing the pressure in soil voids, causes the release of additional VOCs. Extracted gas is either vented to the atmosphere, connected to a vapor-phase carbon adsorption system, or flared, depending on the nature and extent of VOC contamination.

4.5.4.4 Disposal Technologies

Some remedial alternatives will require the disposal of hazardous waste in a RCRA-approved landfill. In addition to RCRA permitting standards, such landfills must meet local, state, and other federal standards, which may result in a decrease in offsite disposal capacity in the future. Onsite RCRA-approved landfills are typically constructed in an uncontaminated area to minimize effects on cleanup operations, on the environment, and on costs and must meet current RCRA standards for design, operations, and closure. Usual components include a primary leachate collection system, a primary liner, a secondary leachate collection (leak detection) system, a composite bottom liner, and a multilayered RCRA cap, together with run-on and run-off controls and environmental monitoring. The Laboratory is proposing to build a Mixed-Waste Storage and Disposal Facility to handle materials with both hazardous and radioactive constituents.

Aqueous solutions (either raw or pretreated waste water), which generally contain low to moderate concentrations of pollutants, may undergo conventional treatment in a municipal waste water treatment plant. This option applies primarily to short-term discharges and to low-flow, longer-term situations, however, and may be a sensitive political issue. Another alternative when suitable land is available is water infiltration, a process in which treated effluent is applied to the soil surface using infiltration trenches, infiltration basins, or spray irrigation.

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1.0 INTRODUCTION

1.1 Background

In 1987, the US Department of Energy (DOE) established its Environmental Restoration (ER) Program as part of the Office of Environmental Restoration and Waste Management (EM), which also houses the Offices of Waste Operations and Technical Development. EM presents its goals, as well as projected schedules and costs, in its annual five-year plan (DOE 1991, 0549). The plan incorporates information provided in site-specific plans for each DOE installation, including Los Alamos National Laboratory (the Laboratory), which is operated by the University of California (UC). The Laboratory established its ER Program as a DOE ER Major Systems Acquisition (ER MSA-1) Project. ER MSA-1 consists of two integrated subprojects: one, the Remedial Action Subproject, hereafter referred to as the ER Program [which is managed by the Environmental Restoration Group (EM-13)], addresses remedial actions at the Laboratory; the other is the Decontamination and Decommissioning (D&D) Subproject, hereafter referred to as the D&D Program [which is managed by the Waste Management Group (EM-7)]. Both groups are part of the Environmental Management (EM) Division (Figure I-1), and both program managers report to the program director of the Applied Environmental Technologies Directorate (Figure I-2), whose roles are listed in Attachment I of this annex. The ER and D&D programs are conducted under the management principles outlined in DOE Order 4700.1, "Project Management System" (DOE 1992, 0823).

1.2 Overview of the ER Program

In November 1989, the New Mexico Environment Improvement Division [now New Mexico Environment Department (NMED)] issued a Resource Conservation and Recovery Act (RCRA) operating permit to the DOE/UC for operating the Laboratory (NMEID 1989, 0595). In addition, on March 8, 1990, the Environmental Protection

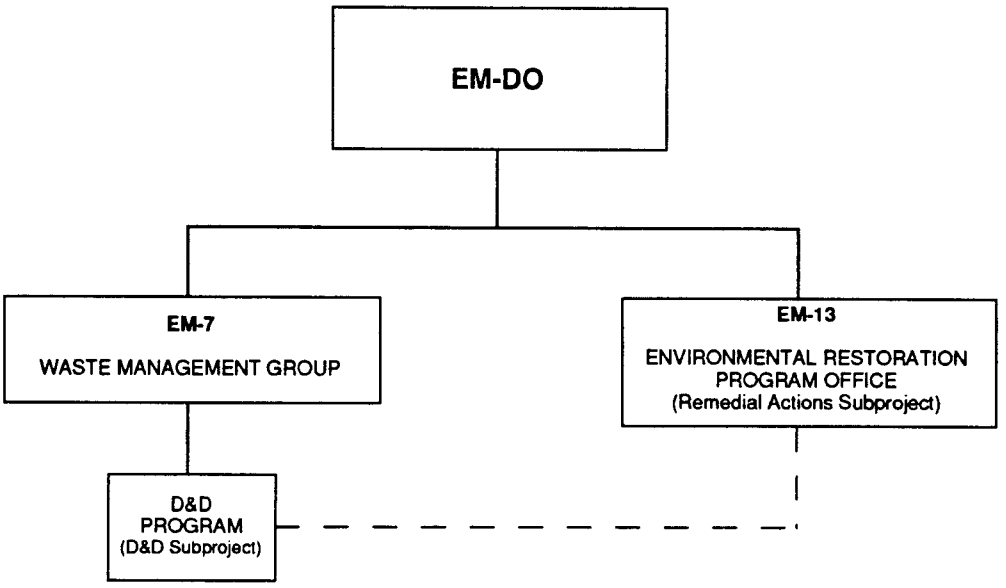

Figure I-1. Relationship of the ER and D&D Programs in the EM Division.

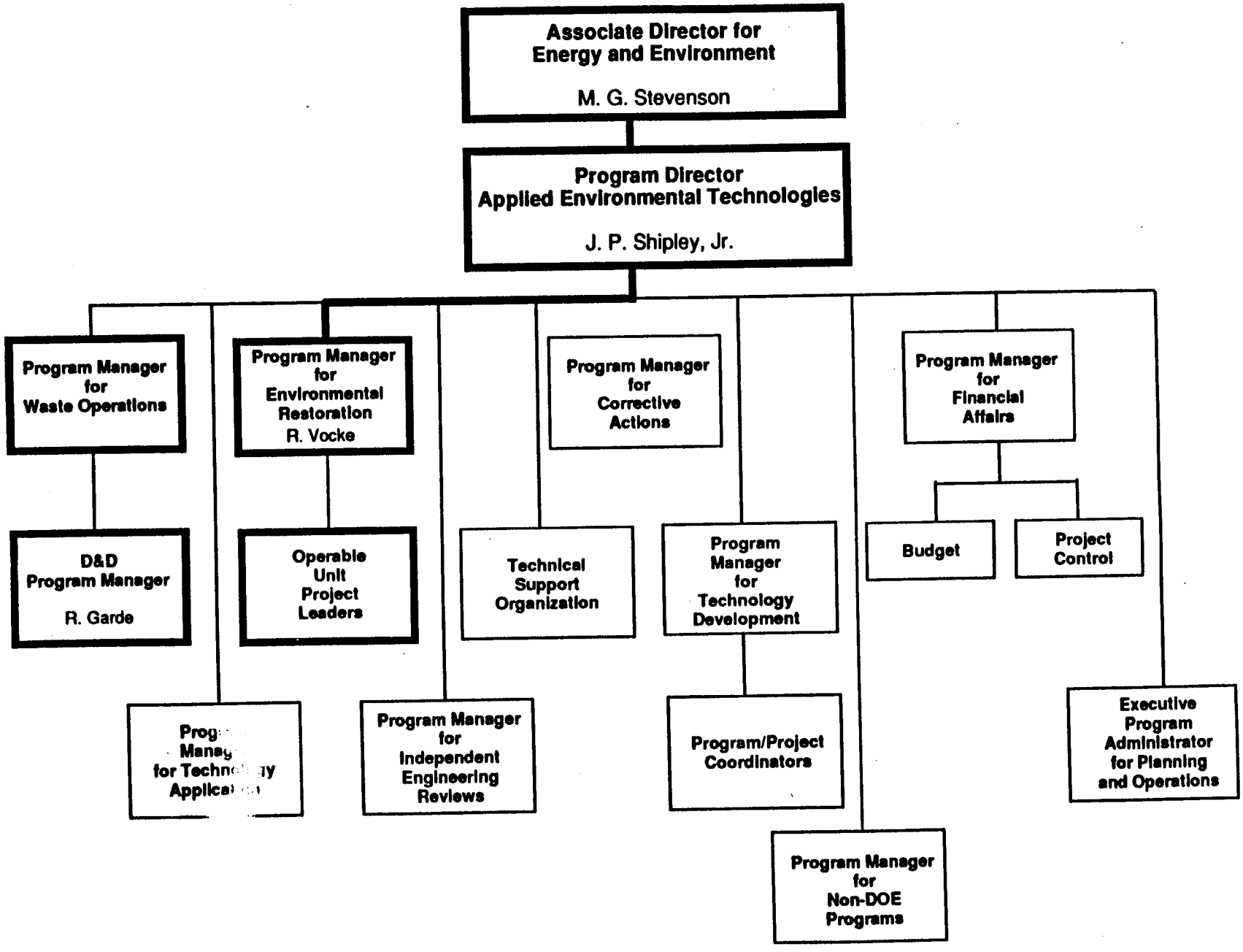

Figure I-2. Program management for the ER MSA-1 Project.

Agency (EPA) issued a Hazardous and Solid Waste Amendments (HSWA) attachment to the permit, known as the HSWA Module, which went into effect on May 23, 1990 (EPA 1990, 0306). The HSWA Module sets forth the procedural requirements for assessing and remediating sites that meet the definition of solid waste management units (SWMUs). In New Mexico, the EPA currently enforces HSWA regulations and will continue to do so until the state legislature enacts measures that satisfy EPA's requirements and the EPA grants the state authority to implement HSWA.

The HSWA Module requires DOE/UC to complete the RCRA facility investigation/corrective measures study (RFI/CMS) portion of the ER Program within 10 years. The purpose of the RFI/CMS is to evaluate existing and potential environmental impacts resulting from contaminated sites and to evaluate corrective measures proposed to mitigate these impacts. All corrective measures implemented at the Laboratory will comply specifically with RCRA regulations and the HSWA Module; with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as appropriate; with the National Environmental Policy Act (NEPA); and with other applicable federal and state laws and regulations.

Laboratory sites that are being investigated include SWMUs and other areas of concern (AOCs), collectively called potential release sites (PRSs), which are aggregated into operable units (OUs) based on the proximity of technical operations. The OUs are assessed by means of the RFI/CMS, and the PRSs are remediated by means of either voluntary corrective actions, corrective measures implementation (CMI), or RCRA closure, as appropriate. The corrective action process mandated by HSWA is shown in Figure I-3.

1.3 Overview of the D&D Program

DOE/EM established the Laboratory's current D&D Program in 1989 to manage nonoperational, contaminated facilities in accordance with guidelines. The D&D Program's primary responsibilities involve facility assessment and cleanup of inactive and surplus contaminated buildings, structures, and equipment not regulated under CERCLA or RCRA. D&D Program subprojects are conducted according to federal and state requirements and DOE orders applicable to nuclear and other facilities that generate radioactive and/or hazardous materials and wastes. The scope of the D&D Program encompasses work that is planned and executed separately from that of the ER Program.

The safe shutdown of facilities is normally not part of the D&D Program; rather, it is the responsibility of the operating organization at the Laboratory. However, in some cases, activities preliminary to the startup of the D&D Program may be required, including removing all stored hazardous and radioactive materials, debris, and waste from process areas; identifying material; and isolating and securing equipment. DOE/EM formally transfers facilities to the Laboratory's D&D Program, at which point the D&D Program follows the process shown in Figure I-4.

1.4 Integration of the ER and D&D Programs

Because PRSs and D&D projects at the Laboratory are frequently collocated, operations of one of these programs often affect operations at the other. Based on this consideration, EM-13 will retain all remedial activities mandated by RCRA and CERCLA. However operable unit project leaders (OUPLs) will task the D&D

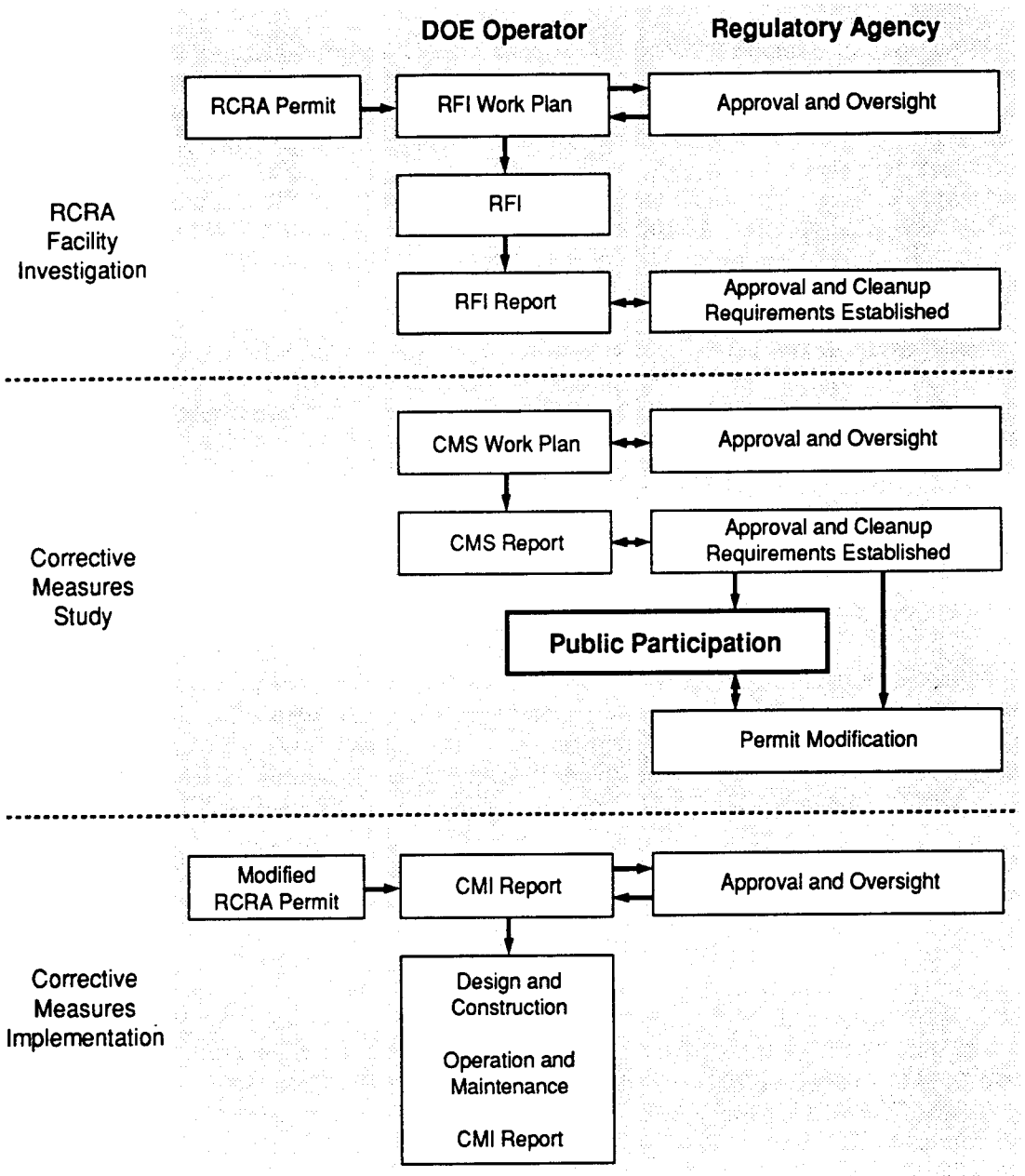

Figure I-3. RCRA corrective action process.

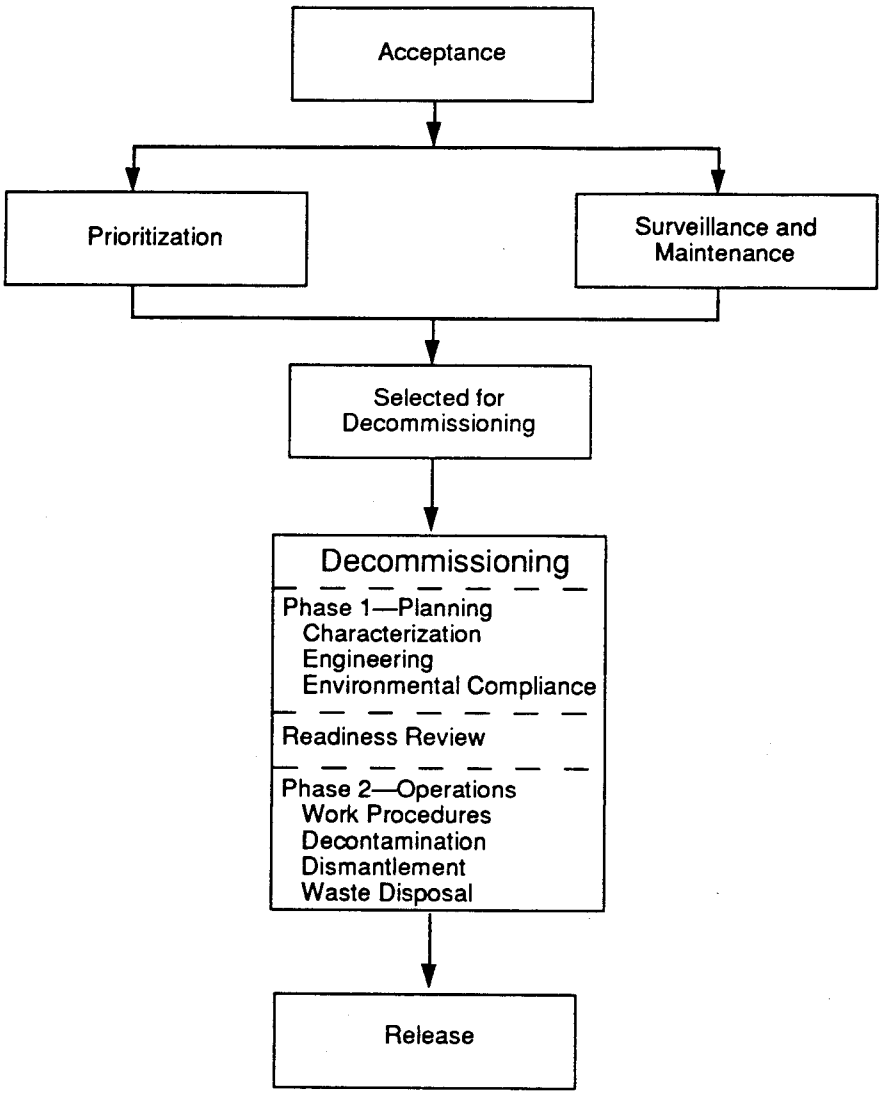

Figure I-4. Phases of a D&D project.

Program to conduct remediation when the necessary remediation is associated with D&D projects (for example, when it is necessary to remove a facility that contains both a PRS and a D&D project). To accomplish this work, EM-13 will transfer funds to EM-7 through approved work scopes. OUPLs and D&D project leaders will develop integrated schedules to achieve regulatory and D&D project milestones.

Remediation under RCRA has priority. If D&D is scheduled significantly before remediation at a PRS, voluntary corrective action at the PRS will be accelerated to coincide with the D&D schedule. Likewise, D&D projects will be accelerated to coincide with remediation scheduled in advance of the beginning of a D&D project at a PRS. In both cases, integrating the schedules depends on the availability of funding. If it is demonstrated that the PRS, such as a waste line associated with a facility, does not require remediation under RCRA or CERCLA, EM-7 will assume complete responsibility, including funding, as authorized, for removal. Early in this process, EM-13 will determine the presence of substances regulated by RCRA and

CERCLA through limited site characterization.

Planning activities must be carefully integrated. EM-13 and EM-7 are providing a common forum, including members of appropriate Laboratory operating groups, to exchange information and to ensure integration of the two programs (for example, EM-13 will provide draft RFI work plans, including schedules, to affected operating groups, and EM-7 will provide draft schedules of its D&D activities).

1.5 Scope

This Program Management Plan sets forth the plans, organization, and systems that DOE/UC will use to manage the ER MSA-1.

The primary responsibility of the ER Program is to formulate, assess, and implement remediation activities required for PRSs and aggregates thereof. The ultimate goal of the ER Program is to bring all PRSs that are under its purview into compliance with applicable environmental regulations and to protect public health and safety and the environment.

The scope of the ER Program includes

- implementing RCRA and CERCLA provisions and remediation and closure of PRSs operated before November 1988, including underground storage tanks;
- conducting CERCLA assessments, as necessary, before real property assets are considered for disposition;
- implementing new technologies necessary to conduct cleanup;
- managing expenses associated with cooperative, multiparty, cleanup plans and activities;
- protecting natural resources and restoring natural resources damaged as the result of past releases of hazardous substances; and
- installing long-term environmental monitoring systems.

The D&D Program is responsible for those activities essential to the decontamination and decommissioning of surplus contaminated facilities at the Laboratory. The scope of the D&D Program includes

- identifying surplus contaminated facilities and developing transfer documentation,
- conducting surveillance and maintenance of facilities, and
- assessing and remediating surplus facilities.

The wastes generated by or associated with the ER and D&D programs are managed by the Laboratory's Waste Management Group (EM-7); waste treatment, storage, and disposal issues are identified early in the project-planning phase to

ensure proper assignment of responsibility and compliance.

1.6 Statutory and Regulatory Requirements

The principal requirements for the ER Program are those derived from RCRA Sections 3004(u) and (v), CERCLA, the Atomic Energy Act (AEA), and New Mexico state law. The ER Program must respond to RCRA requirements for assessing and cleaning up sites at active installations. Section 3004(u) provides for remediation of all hazardous waste sites. Section 3004(v) extends this requirement to contaminated properties located beyond but near the Laboratory boundary. D&D is conducted under the authority of the AEA. CERCLA applies mainly to assessing and remediating inactive sites.

Hazardous materials are regulated both by RCRA and by CERCLA, and radioactive materials are regulated under the AEA and/or CERCLA. The hazardous constituents of mixed waste are also subject to RCRA. New Mexico's authority in the assessment and remediation process is as authorized by the EPA under RCRA. DOE Order 5400.1 (DOE 1988, 0075) establishes the environmental protection program requirements, authorities, and responsibilities for DOE operations to ensure compliance with applicable federal, state, and local environmental protection laws, regulations, and executive orders. In addition, the ER Program complies with Laboratory policies, written as director's policies.

The statutes described in the following sections provide the criteria for evaluating the technical performance of the ER Program. Table I-1 lists the current environmental permits under which the ER Program at the Laboratory operates. The scope and status of other permits that control hazardous waste operations at the Laboratory are the responsibility of the Environmental Protection Group (EM-8).

TABLE I-1

ENVIRONMENTAL PERMITS UNDER WHICH THE ER PROGRAM AT THE LABORATORY OPERATES

Permit Type	Permitted Activity	Issue Date	Expiration Date	Administering Agency
HSWA Module VIII	Environmental Restoration	May 23, 1990	December 31, 1999	EPA
RCRA Hazardous Waste Facility	Hazardous waste storage, treatment, and disposal	November 1990	November 1999	NMED

1.6.1 Resource Conservation and Recovery Act

RCRA governs the generation, transportation, treatment, storage, and disposal of hazardous and solid wastes and provides for the recovery of materials and energy resources from the wastes. HSWA Sections 201, 202, 203, 206, 207, 212, 215, and 224 modified Sections 3004 and 3005 of RCRA. HSWA requires corrective action for all releases of hazardous materials from any SWMU at a treatment, storage, or disposal facility.

Under RCRA, permits are issued by EPA or by states that have received authorization from EPA to administer their own compliance programs. Although the NMED has received authorization to issue RCRA operating permits for managing hazardous and mixed wastes, it is not yet authorized to enforce regulations promulgated under the HSWA.

1.6.2 Comprehensive Environmental Response, Compensation, and Liability Act

CERCLA addresses liability, compensation, cleanup, and emergency response relating to the release of hazardous substances into the environment and cleanup of inactive hazardous waste disposal sites. Under the provisions of the National Contingency Plan, a plan prepared by EPA under CERCLA, the EPA ranks facilities throughout the nation according to their potential hazard to human and environmental health and safety. The higher-ranking facilities listed on the National Priorities List are being assessed and cleaned up first. The Laboratory has not yet been evaluated to determine whether it should be on the National Priorities List.

1.6.3 Integration of the Provisions of RCRA and CERCLA

Even though the Laboratory is a designated RCRA facility and is not on the National Priorities List, certain provisions of CERCLA apply:

- CERCLA applies if hazardous substances are released into the environment or if a substantial threat of release exists.
- CERCLA specifies that the remediation requirement applies equally to federal and nonfederal entities.

1.6.4 Integration of the Provisions of RCRA and NEPA

NEPA provides a national policy to promote efforts that will prevent or eliminate damage to the environment, to enrich the understanding of ecological systems and natural resources, and to establish a Council on Environmental Quality. In accordance with the provisions of DOE Order 5400.4 (DOE 1989, 0078), NEPA procedural requirements and the RCRA process for assessing and cleaning up contaminated sites are integrated. In most cases, the primary instrument for this integration is the RFI/CMS process prescribed by RCRA.

1.6.5 Other Statutes and Regulations

1.6.5.1 Federal Statutes

The following federal acts also affect the conduct of DOE/UC's ER MSA-1 Project:

- The American Indian Religious Freedom Act of 1978 establishes a policy to protect and preserve for native Americans their inherent right to exercise their traditional religions.
- The Atomic Energy Act of 1948, as amended in 1954 and later years, authorizes energy research and development.

- The Clean Air Act of 1970, as amended, regulates emissions from a facility that could affect air quality. Such emissions must meet the performance standards established in this act.

- The Clean Water Act of 1972, as amended, seeks to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The Clean Water Act regulates waste discharges to navigable waters and sets pretreatment standards for hazardous waste discharges to sewer lines that lead to publicly owned treatment works.

- The Department of Energy Organization Act of 1977 vests in DOE the responsibilities of ensuring that national environmental protection goals are incorporated in energy programs; of advancing the goals of restoration, protection, and enhancement of environmental quality; and of ensuring public health and safety.

- The Department of Transportation Act of 1966 defines the US Department of Transportation's regulatory responsibility for safety in the transportation of all hazardous materials, including radioactive materials.

- The Endangered Species Act of 1973, as amended, requires federal agencies, "in consultation with and with the assistance of" the Secretaries of Interior and Commerce, to ensure that their actions are "not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of the critical habitat of such species...".

- The Fish and Wildlife Coordination Act ensures that fish and wildlife resources receive consideration equal to that given other values during the planning of development projects that affect water resources. Final regulations, which were proposed in 1979 and 1980 and were withdrawn in 1982, have not yet been promulgated. Meanwhile, guidance for implementing the Fish and Wildlife Coordination Act is based on court interpretations and past DOE experience.

- The National Historic Preservation Act of 1966 requires federal agencies to take into account the effects of their proposed actions on properties listed on, or eligible for, the National Register of Historic Places.

- The Occupational Safety and Health Act provides for the general welfare by ensuring that, so far as possible, every working man and woman in the nation has safe and healthful working conditions.

- The Safe Drinking Water Act, as amended, defines safety standards for public water systems. The maximum contaminant levels developed under the Safe Drinking Water Act are the levels with which drinking water must comply.

- The Toxic Substances Control Act, as amended, ensures that technological innovation and commerce in chemical substances and mixtures do not present an unreasonable risk of injury to health or the environment. The Toxic Substances Control Act provides for the identification of toxic hazards posed by chemical substances and regulates their discharge into the environment.

1.6.5.2 State Statutes

This section lists state statutes that apply to DOE/UC's ER MSA-1 Project.

- The Air Quality Control Act of 1967 provides the basic framework for air pollution control in New Mexico.

- The Emergency Planning and Community Right-to-Know Act creates an emergency management task force to develop and distribute to emergency response personnel a comprehensive plan for assessing and managing hazardous materials spills. This plan stipulates the requirements for reporting spills and performing cleanup activities.

- The Ground Water Protection Act of 1990 provides for the regulation of hazards associated with leaks and spills from underground storage tanks, containment and remediation of pollution incidents, and funding of groundwater protection activities.

- The Hazardous Chemicals Information Act establishes state-level systems of emergency planning and notification to deal with releases of extremely hazardous substances and to provide a means whereby members of the public can learn about hazardous chemicals used in their communities and about any releases of those chemicals.

- The Hazardous Waste Act of 1977, as amended, establishes the State of New Mexico's program for hazardous waste management and control. Because this act meets federal requirements, EPA has granted the state authority to regulate site closures under RCRA (exclusive of HSWA).

- The Radiation Protection Act (1978) establishes the general rule of radiation protection. The Radiation Protection Act specifies that levels of radiation be kept as low as reasonably achievable, taking into account the state of technology and the costs of improvements in relation to public health and safety benefits and to the use of ionizing radiation in the public interest.

- The Radioactive and Hazardous Materials Act regulates the transportation of radioactive material on highways. Its requirements include a means of transportation that protects the health, safety, and welfare of the citizens and criteria for establishing the safest route.

- The Solid Waste Act of 1990 establishes a comprehensive statewide solid waste management program to regulate the reduction, storage, collection, transportation, separation, processing, recycling, and disposal of solid waste and to promote source reduction, recycling, reuse, treatment, and transformation of solid waste.

- The Water Quality Act gives the New Mexico Oil Conservation Division exclusive authority over the prevention of water pollution resulting from oil or gas operations.

1.6.5.3 DOE Orders, Executive Orders, and Secretary of Energy Notices

The DOE orders that apply to the ER MSA-1 Project are listed below:

DOE 1324.2A	Records Disposition
DOE 1332.1A	Uniform Reporting Systems
DOE 2200.4	Accounting Overview
DOE 2250.1C	Cost and Schedule Control Systems Criteria
DOE 3790.1A	Federal Employee Occupational Safety and Health Program
DOE 4700.1	Project Management System
DOE 5000.3A	Occurrence Reporting and Processing of Operations Information
DOE 5100.3	Field Budget Process
DOE 5400.1	General Environmental Protection Program
DOE 5400.2A	Environmental Compliance Issue Coordination
DOE 5400.3	Hazardous and Radioactive Mixed Waste Program
DOE 5400.4	Comprehensive Environmental Response, Compensation, and Liability Act Requirements
DOE 5400.5	Radiation Protection of the Public and the Environment
DOE 5440.1C	Implementation of the National Environmental Policy Act
DOE 5440.1D	National Environmental Policy Act Compliance Program
DOE 5480.3	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes
DOE 5480.4	Environmental Protection, Safety, and Health Protection Standards
DOE-5480.5	Safety of Nuclear Facilities
DOE 5480.10	Contractor Industrial Hygiene Program
DOE 5480.11	Radiation Protection for Occupational Workers
DOE 5480.20	Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities
DOE 5480.23	Nuclear Safety Analysis Reports
DOE 5482.1B	Environment, Safety, and Health Appraisal Program
DOE 5483.1A	Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities
DOE 5484.1	Environment, Safety, and Health Protection Information Reporting Requirements
DOE 5500.1B	Emergency Management System
DOE 5500.2B	Emergency Categories, Classes, and Notification and Reporting Requirements
DOE 5500.3A	Planning and Preparedness for Operational Emergencies

DOE 5500.4	Public Affairs Policy and Planning Requirements for Emergencies
DOE 5700.2C	Cost Estimating, Analysis, and Standardization
DOE 5700.6C	Quality Assurance
DOE 5700.7B	Work Authorization System
DOE 5820.2A	Radioactive Waste Management
DOE 6430.1	General Design Criteria

The following executive orders (EOs) are applicable to the ER MSA-1 Project:

EO 11988, May 24, 1977	Floodplain Management
EO 11990, May 24, 2977	Protection of Wetlands
EO 11991, May 24, 1977	Relating to Protection or Enhancement of Environmental Quality
EO 12580, January 23, 1987	Superfund Implementation

Secretary of Energy Notices (SENs) applicable to the ER MSA-1 Project are

SEN-7-89, May 19, 1990	Policy on Line Management's Responsibility to Achieve Environmental Compliance
SEN-15-90, February 5, 1990	National Environmental Policy Act (NEPA)
SEN-24-90, June 25, 1990	Strengthening the Department of Energy Project Management System
SEN-25-90, July 24, 1990	Strategic Planning Initiative
SEN-27-90, August 15, 1990	Strengthening the Department of Energy Project Management System

2.0 OBJECTIVES

2.1 Project Management Objectives

The objectives of the DOE/UC's ER MSA-1 Project Management Plan are to

- establish and maintain a management control system and project control procedures for efficient baseline management;
- establish at the Laboratory through the ER Program a procedural framework and schedules for developing, implementing, coordinating, and monitoring corrective actions that comply with RCRA, CERCLA, and NEPA;
- prioritize projects related to resource availability, minimize duplication of analysis and documentation, and expedite corrective actions;
- provide both formal and informal mechanisms through which EPA, NMED, and the public can review, comment on, and participate in the corrective action review process at the Laboratory;
- record plans, procedures, costs, and other data and prepare progress and technical reports so that the knowledge and

experience can be used to manage later elements in a cost-effective manner; and

- coordinate ER and D&D program planning, provide a forum for the exchange of information among affected Laboratory organizations, and ensure integration of the ER and D&D programs.

2.2 Technical Objectives

The overall technical objectives of the ER MSA-1 Project are to effectively formulate, evaluate, implement, and manage characterization, remediation, decontamination, and decommissioning in a manner that fully complies with environmental regulations and protects human health and the environment. These objectives will be met in a cost-effective manner by using existing technologies or through pilot studies that demonstrate the efficacy of simple corrective measures.

The responsibilities and functions of the D&D Program are to

- complete decommissioning activities at all facilities currently designated and at those that may be designated as surplus facilities in the future;
- ensure that decommissioning activities comply with all applicable standards, regulations, and codes and use the most recent technology available;
- maintain surplus facilities awaiting decommissioning in safe and secure states to eliminate potential hazards to the public and the environment;
- conduct surveillance and maintenance and D&D activities in a cost-effective manner;
- establish Laboratory procedures for and assist in the transfer of surplus contaminated facilities; and
- plan and support D&D research and development.

2.3 Quality Assurance Objectives

The intent of all quality programs is to ensure that appropriate controls are built into a program, project, or activity; that the quality of the results is known and documented; and that the effectiveness of the controls, as implemented, can be evaluated. The Laboratory's Quality Program Plan states the quality assurance (QA) objectives and requirements applicable to the ER MSA-1 Project, and activities are planned, implemented, and maintained as required by the Laboratory's Quality Program Plan.

The ER MSA-1 Quality Program Plan has been prepared in accordance with Interim Guidelines and Specifications for Preparing Quality Assurance Program Plans (EPA 1980, 0283) and NQA-1, Quality Assurance Requirements for Nuclear Facilities

(ANSI/ASME 1989, 0018), as specified by DOE Order 5700.6C (DOE 1991, 0703). The intent of the plan is to present a comprehensive, coherent QA program. Personnel implement the guidelines established in the Quality Program Plan through quality assurance project plans (QAPjPs), quality administrative procedures (QPs), and standard operating procedures (SOPs).

2.4 Health and Safety Objectives

The ER MSA-1 Project is committed to performing its work in a manner that protects the health and safety of Laboratory workers and the public through compliance with all applicable federal, state, and local laws and regulations; with all applicable DOE orders and health and safety standards for the Laboratory; and with the health and safety requirements specified in the HSWA Module.

The Health and Safety Program Plan (Annex III) describes the health and safety issues of the corrective action process; is designed to identify, evaluate, and control safety and health hazards; and provides for emergency responses appropriate to the potential hazards of waste characterization and remediation operations. The Health and Safety Program Plan addresses the structure of the health and safety organization of the ER MSA-1 Project, employee training, medical surveillance, monitoring in the field for ionizing radiation and respiratory hazards, measures taken to control access, decontamination procedures, emergency responses, and safety briefings for workers. Audits are regularly conducted to ensure that the Health and Safety Program Plan is implemented effectively.

2.5 Records Management Objectives

The statutory definition of "records" (44 USC 3301) includes technical data. The term is used in the Records Management Program Plan (Annex IV) to reflect the need to protect all records essential to the ER Program. The specific activities implemented to achieve records management will be delineated in QPs and SOPs developed in cooperation with the Quality Program staff.

The Records Management Program ensures that records are managed to maintain their integrity and to ensure that ER Program actions are documented in an auditable manner. The ER Program Office has established the Records-Processing Facility to receive and process records and the Facility for Information Management, Analysis, and Display to provide program participants and the public with centralized access to information generated by the ER Program. The latter facility includes the hardware and software necessary to capture, display, and analyze data.

ER MSA-1 Project records, including technical data sets, are organized, indexed, and stored in a manner that provides efficient access to a diverse group of users. The information retrieval system is designed to protect the integrity of the data. The development of effective guidelines for handling record packages requires coordination with the quality, health and safety, resource planning, and community relations programs.

2.6 Community Relations Objectives

Laboratory policy requires a proactive approach to disseminating and exchanging ideas affecting the general public and Laboratory employees. In addition, the HSWA

Module specifies that the Laboratory develop a community relations plan (Annex V) to provide public access to information pertaining to the ER Program. To satisfy these requirements, the Laboratory is implementing a community relations plan that

- provides information about technical issues in a timely manner;
- responds to communities' concerns in a manner that encourages two-way communication between the interested parties and the Laboratory;
- reaches the broadest audiences and takes into account a variety of educational backgrounds and technical expertise;
- provides for public comment on ER Program activities as specified by regulation;
- provides a library for the general public that contains documentation on past, current, and proposed ER Program activities;
- encourages public participation as a way of increasing the public's understanding of the ER Program;
- proposing activities for budget-year submittal;
- developing the Laboratory's five-year plan for RFI/CMS/CMI activities and RCRA closures;
- developing the Laboratory's current-year work plan; and
- preparing monthly management reports.

2.7 Procurement Plan Objectives

The ER MSA-1 Project follows the Laboratory's procurement policies and procedures set forth in Chapter 7 of the Laboratory Manual (LANL 1981, 0142), which is based on the federal acquisition regulation, the DOE's acquisition regulation, UC procurement policy, federal laws, and executive orders. Subcontracts are awarded competitively to the maximum extent practicable. Sources are selected in general accord with the procedures of the DOE's acquisition regulation handbook source evaluation board.

3.0 ORGANIZATION AND RESPONSIBILITIES OF MANAGEMENT

The DOE's Albuquerque Field Office (DOE/AL) is responsible for implementing the DOE/AL's ER Program. The DOE/AL ER Project Office consists of three divisions: Region of Southwest Projects, Region of Eastern/Northwestern Projects, and Project Support. The DOE/AL ER Program organizational chart is presented in Figure I-5. The two regional divisions coordinate ER Program activities and oversee remedial actions, whereas Project Support allocates resources, oversees regulatory compliance, and coordinates projects. DOE area offices and the management and operations contractor execute approved assessment and remediation tasks at their

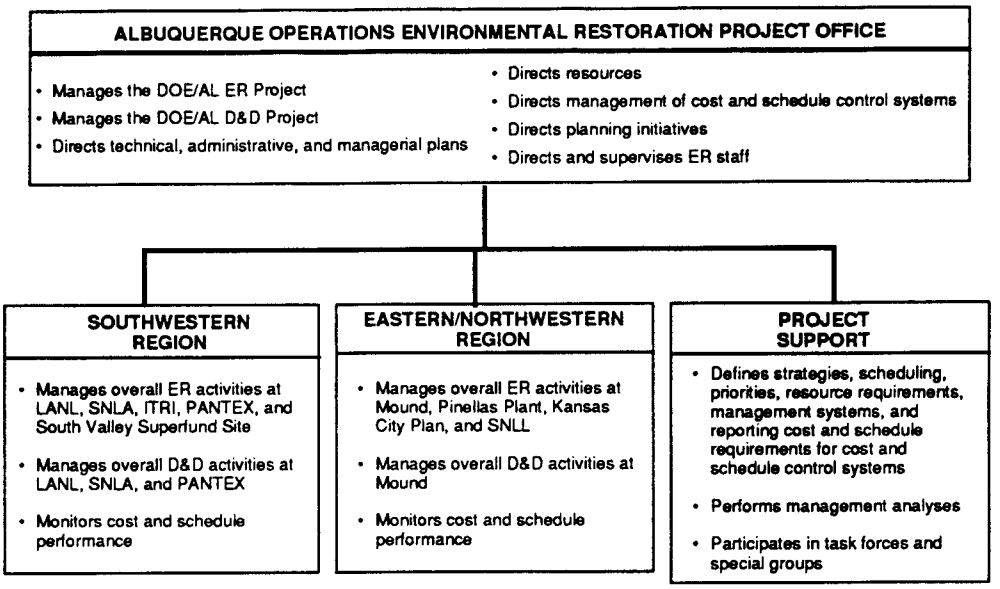

Figure I-5. DOE/AL functional organization chart.

installations. The DOE's Los Alamos Area Office (DOE/LAAO) is the primary line of communication between the Laboratory and DOE/AL for day-to-day operations.

DOE/Headquarters (DOE/HQ) delegates authority for conducting the DOE/AL ER Program to the DOE/AL ER Project Office.

The responsibilities and functions of the ER Program include

- serving as the primary contact (e.g., for conducting negotiations) with regulatory agencies,
- conducting community relations activities,
- conducting RFI/CMS/CMI activities,
- preparing and reviewing RFI/CMS/CMI and NEPA documents,
- distributing RFI/CMS/CMI documents for DOE and regulatory review,
- designing and implementing corrective measures required by and RCRA 3004(u) and 3004(v) and CERCLA,
- conducting activities related to RCRA closures, including NEPA documentation,
- proposing activities for budget-year submittal,
- developing the Laboratory's five-year plan for RFI/CMS/CMI activities and RCRA closures,

- developing the Laboratory's current-year work plan,
- preparing monthly management reports,
- preparing quarterly technical progress reports,
- preparing completion reports for RCRA closures.
- providing information about technical issues in a timely manner,
- responding to communities' concerns in a manner that encourages two-way communication between the interested parties and the Laboratory,
- reaching the broadest audiences and takes into account a variety of educational backgrounds and technical expertise,
- providing for public comment on ER Program activities as specified by regulation,
- providing a library for the general public that contains documentation on past, current, and proposed ER Program activities,
- encouraging public participation as a way of increasing the public's understanding of the ER Program,

The DOE/UC's ER Program organization and responsibilities are presented in Figure I-6. The education and experience of key participants in the program are summarized in Appendix M. The organization of the D&D Program is presented in Figure I-7.

4.0 MANAGEMENT INFORMATION SYSTEM FOR THE DOE/UC'S ER MSA-1 PROJECT

The ER MSA-1 Project's Management Information System (MIS) is based on a management control system developed by DOE/UC consisting of a set of policies, procedures, practices, computer systems, forms, reports, and documents that collectively provide for the systematic and effective management of EM Division projects at the Laboratory.

The MIS collects, processes, and analyzes information for various individuals in the ER Program, including, for example, management staff, project leaders, and technical team leaders (TTLs). Based on these analyses, MIS personnel keep program managers informed of the status

of the program's cost and schedule and identify problems and possible solutions. The D&D Program uses similar project management analysis to develop its baseline and to monitor performance. Because the tasks and methodologies for accomplishing DOE requirements in the ER and D&D programs are nearly identical, this MIS discussion applies to both programs. The Laboratory's Management Control System and applicable project control procedures will be provided in a future version of the IWP.

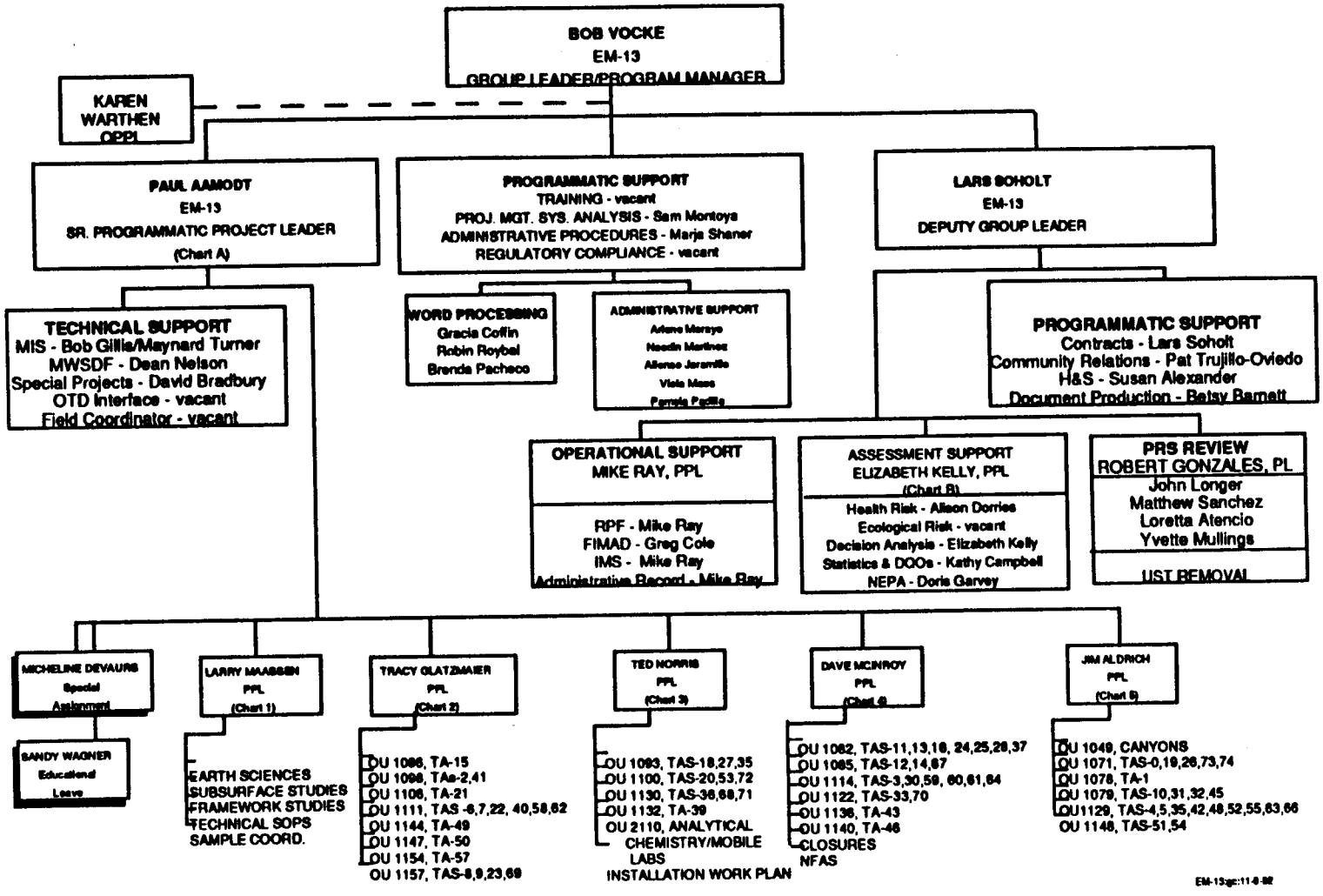

Figure I-6. ER Program Organization Chart.

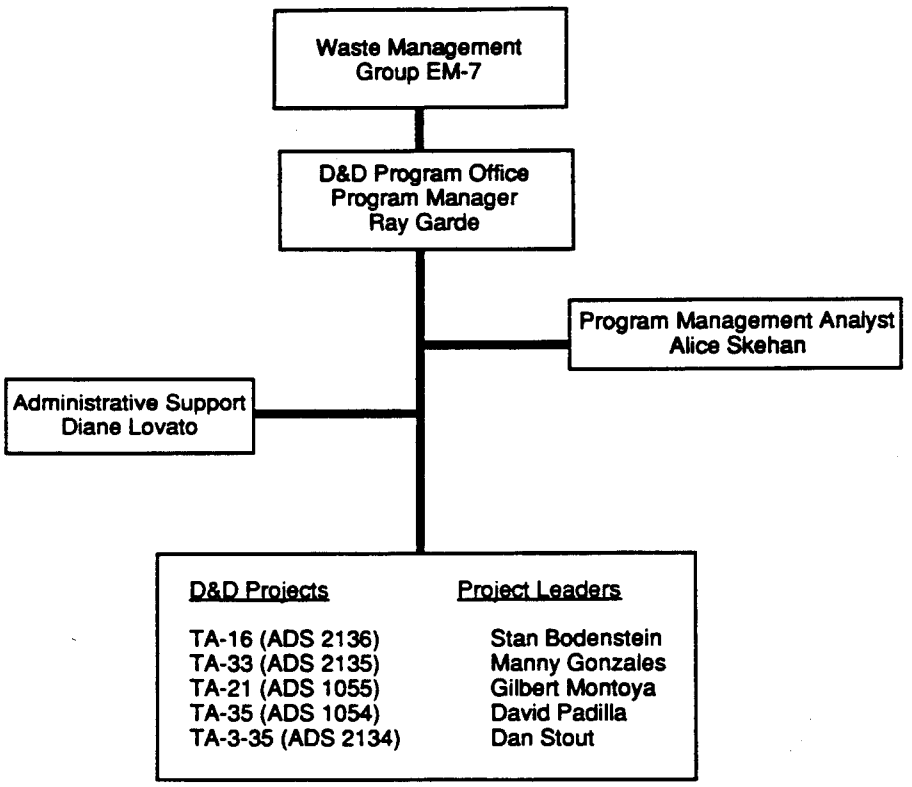

Figure I-7. D&D Program organization chart.

The MIS follows the requirements of DOE Order 4700.1 (DOE 1992, 0823) and addresses

- planning,
- scheduling,
- cost estimating,
- budgeting,
- work authorization,
- cost accounting,
- progress reporting,
- performance measurement, and
- change control.

Under the direction of the program offices, MIS implements guidance of DOE/HQ and DOE/AL. The MIS coordinates a large initial planning effort of all project participants, including the program managers, the project leaders, and the TTLs. All

participants authorized to be cost account managers must analyze and act upon reports of past progress and future activities generated by the MIS each month.

The strict relationship between the Laboratory's program codes and the MIS codes makes it possible to compare efforts on a before-and-after basis to measure performance, which is reported to DOE monthly. When a difference between planned (before) and actual (after) exists in excess of a DOE-specified limit (currently plus or minus 10%), a variance is said to exist. Each variance must be addressed by a statement containing a description of the problem and its cause, impact, and the action required or taken to correct the variance. The responsible parties must make this response and take action, as appropriate.

The ER Program's MIS consists of (1) a work breakdown structure (WBS), (2) a responsibility assignment matrix, (3) logic networks, (4) a network-based schedule, (5) detailed cost estimates based on network activities, and (6) actual cost information from the Laboratory's accounting department (FIN-3). All six components of the MIS are integrated into a highly disciplined and dynamic system baseline.

The WBS is used to define a project by relating elements of work to each other and to the end product. This is the primary tool that DOE uses to identify its project elements and responsibilities. It conveniently formats the relationship of all project elements and provides a sound basis for planning and controlling technical costs and schedules. Each level of the structure is closely related to a management sphere within a program and provides the framework for relating time and cost summaries to appropriate levels of contractor, UC, and DOE management. A WBS provides both a basis and an integrating mechanism for managing key functions of a program and all subprojects.

Figure I-8 is the WBS currently used by DOE/UC's ER Program. The fundamental units of the WBS are the OUs, management, closure, and other activities (Tables I-2 and I-3) shown in the fourth level of Figure I-8. Each one consists of one of the activity data sheets (ADSs) contained in the current five-year plan. The ADS serves as DOE/UC's tool for projecting costs and schedules and requesting budget allocations.

The following documents describe the policy for managing the ER MSA-1 work for the DOE and are pertinent to the use of the WBS and operation of the MIS:

- OMB Circular A-109, Major System Acquisitions (OMB 1976, 0366);
- DOE Order 4700.1, Project Management System;
- DOE Order 4240.J, Designation of Major System Acquisitions and Major Projects;
- DOE Order N 4700.5, Project Control System Guidelines and
- DOE Order 1332.1A, Uniform Reporting System.

Briefly, the MIS functions as follows: The WBS defines the work elements and objectives to be attained. A logic network, composed of tasks defined as time- and resource- consuming elements of work, is then developed to produce a schedule of activities, including milestones.

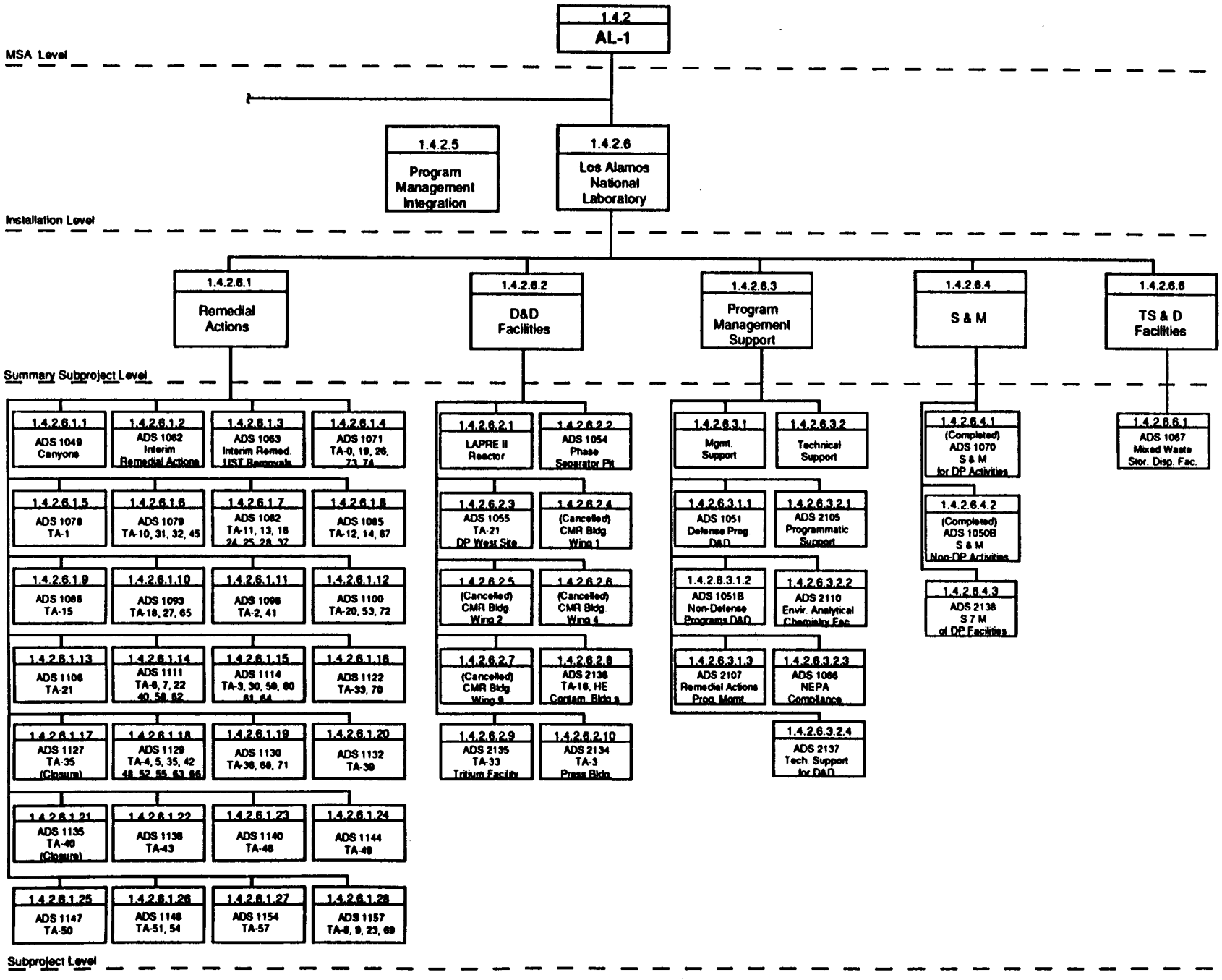

Figure I-8. WBS currently used by DOE/UC's ER MSA-1 Project.

TABLE I-2

SUMMARY SCHEDULE OF ER PROGRAM ACTIVITIES

ADS Number	Technical Area(s)
Work plan to EPA May 1991	
1106	TA-21
Eight work plans to EPA May 1992	
1071	TAs-0, -19, -26, -73, -74
1078	TA-1
1079	TAs-10, -31, -32, -45
1122	TA-33, -70
1129	TAs-4, -5, -35, -42, -48, -52, -55, -63, 66
1144	TA-49
1147	TA-50
1148	TAs-51, -54
Ten work plans to EPA May 1993	
1082	TAs-11, -13, -16, -24, -25, -28, -37
1086	TA-15
1093	TAs-18, -27, -65
1098	TAs-2, -41
1111	TAs-6, -7, -22, -40, -58, -62
1114	TAs-3, -30, -59, -60, -61, -64
1130	TAs-36, -68, -71
1132	TA-39
1140	TA-46
1157	TAs-8, -9, -23, -69
Four work plans to EPA May 1994	
1085	TAs-12, -14, -67
1100	TAs-20, -53, -72
1136	TA-43
1154	TA-57
One work plan to EPA May 1995	
1049	Canyons

Cost estimates are either generic throughout the project (e.g., the cost of developing a community relations plan, which is a requirement for each OU) or are developed by the OUPLs in cooperation with cost estimators. Most cost estimates, however, are highly specific (e.g., estimates of the number of PRSs and D&D facilities identified at a site, the size of the PRSs and D&D facilities, and the physical location and grouping of sites). All estimates are prepared using the guidelines set forth in DOE Order 4700.1 (DOE 1992, 0823) and the DOE's cost-estimating, analysis, and standardization guidelines (DOE Order 5700.20).

The responsibility assignment matrix allocates resources to activities and ensures that all work in the WBS is assigned. Because the matrix integrates the planning and scheduling and the cost-estimating programs, all estimates are produced as a function of time. The matrix is also used to establish and control cost accounts. By

TABLE I-3

SUMMARY SCHEDULE OF D&D PROGRAM ACTIVITIES

ADS No.	Operable Unit Description	Start Date
1051	Defense Facilities Management	10/91
1051-B	Nondefense Facilities Management	10/92
1054	TA-35, Phase Separator Pit D&D	
	Assessment	09/92
	Remediation	04/93
1055	DP West Site D&D	
	TA-21, Buildings 3 & 4, South D&D	
	Assessment	07/89
	Remediation	10/92
	TA-21, All Other Buildings D&D	
	Assessment	10/93
	Remediation	05/94
2134	TA-3, SM-35, Press Building D&D	
	Assessment	10/93
	Remediation	05/94
2135	TA-33, Building 33, Tritium Facility D&D	
	Assessment	10/93
	Remediation	01/94
2136	TA-16, HE Contaminated Site D&D	
	Assessment	10/93
	Remediation	10/93
2137	D&D Program Technical Support	10/94
2138	DP Facilities Surveillance and Maintenance	10/94

comparing the estimated costs with actual reported costs, estimators are able to measure performance monthly.

Because the MIS addresses in a highly integrated manner a combination of what, how, who, when, and how much, it is also possible for planning purposes to create future scenarios and to determine their impacts before decisions are actually implemented.

The MIS is described in detail in the Management Control System Manual, Environmental Management Division (LANL 1991, 0547), and in the Project Control Procedures (LANL 1991, 0548).

5.0 ER MSA-1 PROJECT SCHEDULE

Major milestones that have been identified for the RFI/CMS/CMI include

- complete RFI work plan,
- complete RFI,
- complete RFI report,
- complete CMS plan,
- complete CMS,
- complete CMS report,
- complete CMI plan,
- complete CMI, and
- complete CMI report.

Phase (interim) reports will be prepared throughout the corrective action process to document important findings and events.

These milestones apply to individual OUs, not to the ER Program as an entity. As more information becomes available from the RFI, CMS, CMI, and associated investigations at individual OUs, detailed, achievable plans will be developed and refined to meet regulatory due dates.

D&D Program milestones are project-dependent. Typical milestones are

- complete facility acceptance,
- complete surveillance and maintenance plan,
- complete assessment,
- complete project readiness review,
- complete remediation, and
- complete final report.

DOE/UC do not believe that the health and environment risks associated with any of the Laboratory's SWMUs or other PRSs warrant prioritization based solely on risk; therefore, OUs are scheduled for corrective action based on the HSWA Module. The HSWA Module schedule requires that DOE/UC complete RFI work plans for 10% of the SWMUs and 20% of the priority SWMUs listed in Table I-4 by May 23, 1991, one year after the effective date of the module. In the second year (ending May 23, 1992), work plans must be completed for an additional 25% and 35% of the listed SWMUs, respectively; in the third year (ending May 23, 1993), 20% and 45% of the listed SWMUs, respectively; and the remaining SWMUs, in the fourth year (ending May 23, 1994).

TABLE I-4

HSWA MODULE SWMUS AND PRIORITY SWMUS

Technical Area	SWMUs	Priority SWMUs
0	11	3
1	16	16
2	6	2
3	61	8
4	2	0
5	6	1
6	6	1
7	2	0
8	11	4
9	33	2
10	15	7
11	14	8
12	2	0
13	2	1
14	9	0
15	30	18
16	88	18
18	14	9
19	1	0
20	5	0
21	68	37
22	9	1
27	7	0
31	1	0
32	2	0
33	28	4
35	35	22
36	6	3
39	13	5
40	10	0
41	4	1
43	1	0
45	3	0
46	28	6
48	5	0
49	2	1
50	11	2
52	15	0
53	11	0
54	10	3
59	1	0

The HSWA Module currently requires that the RFI/CMS be completed within 10 years. The 10-year schedule was based on the 603 SWMUs listed in the HSWA Module, not on the total number of sites listed in the PRS data base (as currently updated) that will be addressed under the 24 OUs. With EPA's approval of a pending proposal to modify the permit, DOE/UC will address all SWMUs as designated by the EPA. If sufficient resources, including funds, manpower, and analytical capacity, prove to be unavailable over the course of the ER Program, DOE/UC may invoke the provisions of the HSWA Module to request further extensions.

OU planning and schedule information is presented in Appendix N. Because budget estimates for FY93 and FY94 are not yet finalized, the funding estimates in Appendix N are approximations that may change. Table I-5 provides a cost/schedule breakdown for current ADSs.

TABLE I-5

ADS SCHEDULE/COST BREAKDOWN
(Estimated as of October 1, 1992)

ADS	Schedule Start	Schedule Completion	Cost ($1000s)
1049: CANYONS ASSESSMENT	10-2-89*	9-29-15	210,482
1062: INTERIM REMEDIAL MEASURES	10-1-89*	3-31-92*	1,719
1063: INTERIM REMEDIAL MEASURES—USTs	10-2-89*	9-30-92*	1,340
1066: NEPA DOCUMENTATION	5-1-90*	3-16-95	3,504
1067: RCRA MWSDF	6-16-90*	9-27-96	17,706
1071: TA-0, -19, -26, -73, -74 ASSESSMENT	10-19-90*	9-30-03	69,795
1078: TA-1 ASSESSMENT	2-1-90*	8-16-99	18,580
1079: TA-10, -31, -32, -45 ASSESSMENT	4-2-90*	9-30-04	53,046
1082: TA-11, -13, -16, -24, -25, -28, -37 ASSESSMENT	10-1-91*	9-28-18	318,041
1085: TA-12, -14, -67 ASSESSMENT	10-1-92	9-30-99	10,063
1086: TA-15 ASSESSMENT	10-1-91*	9-30-03	31,685
1093: TA-18, -27, -65 ASSESSMENT	10-1-91*	9-30-98	15,263
1098: TA-2, -41 ASSESSMENT	10-1-91*	9-30-04	71,970
1100: TA-20, -53, -72 ASSESSMENT	10-1-92	8-18-04	47,332
1106: TA-21 ASSESSMENT	10-2-89*	9-30-11	159,725
1111: TA-6, -7, -22, -40, -58, -62 ASSESSMENT	10-1-90*	9-28-01	28,477
1114: TA-3, -30, -59, -60, -61, -64 ASSESSMENT	10-1-91*	9-28-12	82,162
1122: TA-33, -70 ASSESSMENT	4-2-90*	9-30-03	17,904
1127: TA-35 WASTE OIL PITS CLOSURE	10-2-89*	3-26-93	1,198
1129: TA-4, -5, -35, -42, -52, -55, -63, -66 ASSESSMENT	11-1-90*	9-30-13	130,202
1130: TA-36, -68, -71 ASSESSMENT	10-1-91*	9-28-01	14,498
1132: TA-39 ASSESSMENT	10-1-91*	9-29-06	44,343
1135: TA-40 SDS SITE CLOSURE	11-1-90*	2-3-93	571
1136: TA-43 ASSESSMENT	10-1-92	9-30-99	2,828
1140: TA-46 ASSESSMENT	10-1-91	9-30-98	16,229
1144: TA-49 ASSESSMENT	7-2-90*	9-30-03	16,385
1147: TA-50 ASSESSMENT	4-6-90*	9-30-05	49,786
1148: TA-51,54 ASSESSMENT	10-2-92*	9-29-06	89,813
1154: TA-57 ASSESSMENT	10-1-92	9-30-98	3,067
1157: TA-8, -9, -23, -69 ASSESSMENT	12-2-91*	9-30-08	39,968
2105: PROGRAMMATIC TECHNICAL SUPPORT	10-1-90*	9-13-19	273,380
2107: ASSESSMENT MANAGEMENT	10-2-89*	9-28-18	507,450
2110: ENVIRON. ANALYTICAL SUPPORT	11-1-90*	9-28-18	35,489
(1082) 1091: TA-16 ASSESSMENT	10-88*	9-90*	31
(1148) 1150: TA-54 ASSESSMENT	4-2-90	5-8-91*	75
		TOTAL	2,384,107

*Denotes actual start or completion dates.

6.0 REPORTING REQUIREMENTS

The development and implementation of reporting requirements for the ER Program are mandated by DOE and by other responsible regulatory agencies through DOE/UC's permit to operate under RCRA. DOE/LAAO and UC, as co-permittees, must sign the following certification for each deliverable to EPA, including monthly and quarterly technical progress reports.

> I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

All reporting data and documentation requirements conform to DOE Order 4700.1 and comply with applicable guidance from DOE/HQ, DOE/AL, DOE/LAAO, and internal UC criteria. The documents required by regulation for the Laboratory's ER Program are shown in Table I-6.

To comply with applicable regulations and to keep all interested parties informed of progress made during the corrective action process, the ER Program prepares several types of plans and reports. The major plans and reports are associated with the RFI, CMS, and CMI. In addition, OUPLs prepare monthly reports, quarterly technical progress reports, and phase reports (Section 3.5.1.2.2). The technical progress report requirements set forth in the HSWA Module for the ER Program (i.e., the facility summary) are presented in Table I-7.

It is the policy of the ER Program Office to see that all reports comply, to the extent feasible, with EPA's RFI guidance and DOE guidance regarding compliance with CERCLA. At a minimum, the reports describe the procedures, methods, and results of field investigations and include information on the type and extent of contamination, sources and migration pathways, and actual and potential receptors. The reports contain information adequate to support further corrective action decisions (e.g., comparisons with screening action level criteria). OUPLs make all reports available to the public through the community reading room.

In addition, the D&D Program prepares formal Laboratory reports upon completion of a D&D project. The formal report provides background information, characterization data, D&D methods and techniques, final survey and release data, and any lessons learned. The purpose of the final report is to capture project history, and provide a formal record of completion.

TABLE I-6

PRIMARY DOCUMENTS REQUIRED BY REGULATION

Type	Frequency	Due Date To DOE/AL	UC	DOE/LAAO	DOE/AL	Regulatory Agency
Installation Work Plan	A	NA	P	R	R	AP
RFI OU Work Plans	NA	NA	P	R	R	AP
RCRA Closure Plans	NA	NA	P	R	R	AP
RFI Reports	NA	NA	P	R	R	AP
CMS Plan	NA	NA	P	R	R	AP
CMS Reports	NA	NA	P	R	R	AP
Interim Measures Plans	NA	NA	P	R	R	AP
Monthly Management Reports	M	M	P	R	R	NA
Quarterly Technical Progress Reports	Q	NA	P	R	NA	NA
Phase Reports	AR	AR	P	AP	AP	AP

NA = Not applicable
IN = Input
P = Prepare
A = Annual
M = Monthly
R = Review
AP = Approve
AR = As required
Q = Quarterly

TABLE I-7

TECHNICAL PROGRESS REPORTING REQUIREMENTS FOR OPERABLE UNITS

Document	EPA	DOE	NMED	Due Date
Monthly	X	X	X	Following month
Quarterly	X	X	X	Following quarter
Phase Reports	X	X	X	As approved by DOE and EPA

References for Annex I

ANSI/ASME (American National Standards Institute/American Society of Mechanical Engineers) 1989. "Quality Assurance Requirements for Nuclear Facilities," NQA-1-1989, 345 East 47th Street, New York, New York. (ANSI/ASME 1989, 0018)

DOE (US Department of Energy), November 9, 1988. "General Environmental Protection Program," DOE Order 5400.1, Washington, DC. (DOE 1988, 0075)

DOE (US Department of Energy), October 6, 1989. "Comprehensive Environmental Response, Compensation, and Liability Act Requirements," DOE Order 5400.4, Washington, DC. (DOE 1989, 0078)

DOE (US Department of Energy), September 1990. "Cost-Estimating Handbook for Environmental Restoration," Rev. 0, Office of Environmental Restoration and Waste Management, Washington, DC. (DOE 1990, 0272)

DOE (US Department of Energy) 1990. "Environmental Restoration On-Site Remediation Program Management Plan," (draft), Office of Environmental Restoration and Waste Management, Washington, DC. (DOE 1990, 0276)

DOE (US Department of Energy), August 1991. "Five-Year Plan: Fiscal Years 1993-1997," National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. (DOE 1991, 0549)

DOE (US Department of Energy), August 21, 1991. "Quality Assurance," DOE Order 5700.6C, Office of Nuclear Energy and Office of Environment, Safety, and Health, Washington, DC. (DOE 1991, 0703)

*DOE (US Department of Energy), June 6, 1992. "Project Management System," DOE Order 4700.1, Change 1, Washington, DC. (DOE 1992, 0823)

*EPA (US Environmental Protection Agency) 1980. "Interim Guidelines and Specifications for Preparing Quality Assurance Program Plans," QAMS-004/80, Washington, DC. (EPA 1980, 0283)

*EPA (US Environmental Protection Agency), December 29, 1980. "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," QAMS-005/80, Office of Monitoring Systems and Quality Assurance, Office of Research and Development, Washington, DC. (EPA 1980, 0552)

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, 0306)

LANL (Los Alamos National Laboratory), October 1981. "The Laboratory Manual, Procurement Policies and Procedures," Los Alamos, New Mexico. (LANL 1981, 0142)

*LANL (Los Alamos National Laboratory), September 1982. "Work Breakdown Structure Dictionary," Environmental Restoration Program, Environmental Management Division, Los Alamos, New Mexico. (LANL 1982, 0807)

LANL (Los Alamos National Laboratory), September 30, 1991. "Management Control System Manual" (draft), Environmental Management Division, Los Alamos, New Mexico. (LANL 1991, 0547)

LANL (Los Alamos National Laboratory), September 30, 1991. "Project Control Procedures" (draft), Environmental Management Division, Los Alamos, New Mexico. (LANL 1991, 0548)

NMEID (New Mexico Environmental Improvement Division) November 8, 1989. "Hazardous Waste Facility Permit," Permit No. NM0890010515-1 issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective February 19, 1990, Santa Fe, New Mexico. (NMEID 1989, 0595)

*OMB (Office of Management and Budget), April 5, 1976. "Major System Acquisitions," Circular A-109, Washington, DC. (OMB 1976, 0366)

ATTACHMENT I

EM/AET ROLES AND RESPONSIBILITIES

EM-DIVISION LEADER

- Lead in executing ER/WM operations at Los Alamos; provide and oversee the necessary technical and staff resources.

- Lead in compliance activities
  - -- Lead interactions with the regulatory agencies.
  - -- Track and implement regulatory changes/orders
  - -- Define programmatic requirements for compliance.
  - -- Provide compliance technical support to the Laboratory.
  - -- Ensure ES&H compliance for EM-Division efforts.
  - -- Manage institutional programs.

- Serve as the Office of Primary Responsibility for Director's Policies on ER/WM operations.

- Help plan and implement Five-Year Plan activities.

- Ensure timely, quality preparation of contributions to programmatic efforts such as baselines and reports.

- Be in a position to know and be credible about technology development and industrial relations programs.

- Be informed of Change-Control Requests affecting EM-Division; approve those above some threshold.

AET PROGRAM DIRECTOR

- Lead in directing and ensuring performance of ER/WM programs at Los Alamos; provide program resources and guidance.

- Lead in program development
  - -- Create new programs to address emerging needs.
  - -- Coordinate multiorganizational programs.
  - -- Ensure cost-effective technology development and utilization.
  - -- Encourage industrial relations.

- Track/respond to environmental developments from the overall program viewpoint.

- Lead the Laboratory's strategic planning for ER/WM program development and execution.

- Review and approve the Five-Year-Plan.

- Validate programmatic efforts
  - -- required cost/pricing done internally by FIN Division.
  - -- provide independent content/quality examination.

- Be in a position to know and be credible about all the programs.

- Be informed of all Change-Control Requests; approve those above some threshold.

MUTUAL

- Strive for consensus decisions on programmatic matters.
  -- AET to lead in creating the opportunity for consensus.
  -- EM to lead in devising win-win solutions.

- Provide effective evaluations and incentives for the appropriate program managers, taking into account the views of both the Division Leader and the Program Director.

- Perform communications and outreach, including engaging in DOE/HQ, AL, and LAAO interactions.

- Encourage waste minimization
  -- EM to do: a) operational planning for the Laboratory
  b) waste minimization for EM operations
  -- AET to do: a) waste minimization program development
  b) waste minimization program coordination

- Keep management informed of significant events.

- Pursue quality and excellence relentlessly.

GROUP LEADER

- Under the supervision of the Division Leader, manage the day-to-day affairs of the group:
  - -- hire/contract for in-group staff and technical resources
  - -- develop personnel and group technical capabilities
  - -- carry out group budgeting and planning
  - -- use group technical resources to execute agreed-on cost/schedule/scope baselines
  - -- ensure group performance and quality.
- Assist/participate in interactions with the sponsors, as appropriate at all levels.
- Contribute to the Laboratory's strategic planning efforts.
- Prepare the applicable portions of the Five-Year Plan and other programmatic documents.
- Oversee the generation of Change-Control Requests; review and approve those that affect the group.
- Ensure that group efforts comply with applicable rules, regulations, and DOE Orders.

PROGRAM MANAGER

- Under the supervision of the Program Director, manage the day-to-day affairs of the program element:
  - -- obtain cross-organization resources
  - -- take advantage of emerging capabilities and technology; develop the program accordingly.
  - -- carry out program budgeting and planning
  - -- create and pursue agreed-on cost/schedule/scope baselines
  - -- ensure program element performance and quality
- Coordinate interactions with the sponsors, working with the Area and Field Offices.
- Coordinate the Laboratory's strategic planning within the program element.
- Supervise program element preparation for the Five-Year Plan and other programmatic documents.
- Review and approve all program element Change-Control Requests.
- Working through the program participants, ensure that program efforts comply with applicable rules, regulations, and DOE Orders.

1.0 INTRODUCTION

The Environmental Restoration (ER) Program Office (EM-13) at Los Alamos National Laboratory (the Laboratory) builds quality into all program work processes by planning, organizing, directing, and controlling ER Program activities. The ER Program ensures the quality of data by providing written technical plans and procedures in accordance with Environmental Protection Agency (EPA) and Department of Energy (DOE) guidance and requirements. Plans and procedures are evaluated through formal internal and external review processes to ensure technically adequate documents. Qualified and properly trained personnel collect and analyze data and provide documentation of all aspects of planning and sampling activities.

The purpose of this annex is to identify the documents that contain quality assurance (QA) requirements applicable to the ER Program, to describe the QA procedures used to ensure the quality of data collected under the ER Program, and to describe the guidance provided to ER Program participants by the ER Program Office.

2.0 OVERVIEW OF ER PROGRAM DOCUMENTS

The planning, guidance, and requirements documents introduced below are used by ER Program personnel, including contractors, to develop their individual plans and procedures. Additionally, the guidance and requirements provide instructions for many functions and apply to, or are incorporated in, individual ER work processes, as appropriate.

2.1 Installation Work Plan

The Installation Work Plan (IWP) (LANL 1992, 0768) describes the overall mission, organization, and functional responsibilities of the ER Program. Each chapter and annex in the IWP provides essential information for ensuring the quality of program work processes. The IWP provides information that pertains to the entire program so that individual plans and procedures can incorporate generic information by reference to the appropriate location in the IWP. The IWP is distributed to programmatic project leaders, operable unit project leaders, technical team leaders, and other program participants, as appropriate.

2.2 Quality Program Plan and Procedures

The Quality Program Plan (QPP) for the ER Program (LANL 1991, 0781) was approved by EPA on July 12, 1991. The QPP states the basic QA requirements that DOE and EPA require for ER Program activities. It is the responsibility of each program participant to incorporate these requirements in his/her work processes.

The requirements of the QPP are implemented through standard operating procedures (SOPs) (LANL 1991, 0411), administrative procedures (APs), and quality procedures (QPs) developed specially for the ER Program and through the IWP. ER Program participants execute Laboratory or contractor procedures, as appropriate. The QPP and appropriate procedures are distributed to program personnel on an as-needed basis via controlled distribution.

2.3 Generic Quality Assurance Project Plan

The Generic Quality Assurance Project Plan (QAPjP) (LANL 1992, 0782), which was approved by the EPA on July 12, 1991, was designed to serve as a framework for preparing QAPjPs specific to each of the ER Program's 24 operable units. Although previously included in the IWP, beginning in 1992, the generic QAPjP will be issued separately via controlled distribution to ER Program project leaders responsible for developing Resource Conservation and Recovery Act facility investigation (RFI) work plans for each operable unit.

3.0 ER PROGRAM'S APPROACH TO DATA COLLECTION

The strategies for collecting data are described in individual RFI work plans. Guidance for developing investigation strategies is provided in the generic QAPjP and in the IWP, Chapter 4, Technical Approach. The requirements and guidance to assess analytical data precision, accuracy, representativeness, and completeness of measurement data are described in the generic QAPjP.

3.1 Data Usage

As stipulated in the generic QAPjP, individual RFI work plans describe the intended uses of data and the necessary level of precision and accuracy for the intended uses.

3.2 Data Assessment

The methods and procedures used to assess field data are located in the SOP manuals issued via controlled distribution. The SOPs are revised, as necessary, in accordance with APs and are distributed to manual holders.

The methods and procedures used to assess analytical data are located in a Laboratory health and environmental chemistry guidance document (LANL no date, 0520). This controlled document is maintained by the Laboratory's Health and Environmental Chemistry Group (EM-9).

3.3 Sampling and Field Measurements

The technical approach to determining sample collection strategies and decisions is included in Chapter 4 of the IWP. For example, applying the data quality objectives (DQO) process (EPA 1987, 0086) described in Chapter 4 enables the operable unit project leader to select appropriate sampling and field measurements, locations, depths, and number of samples for individual sampling plans. Additionally, the work plans identify sampling and field measurement sites in sufficient number to provide statistical accuracy and to describe the conditions under which sampling and field measurements should be conducted.

At a minimum, the QAPjP and SOPS describe administrative and field readiness review procedures; identify field sampling operations and techniques; and describe appropriate sample containers, sample preservation, and field documentation requirements, including, chain-of-custody requirements.

Procedures developed by other organizations, both internal and external to the Laboratory, are used when ER Program procedures do not exist.

3.4 Sample Analysis

The procedures for sample analysis, including EPA methods, are maintained by the Health and Environmental Chemistry Group (EM-9). EM-9 also maintains analytical procedures in its health and environmental chemistry guidance document (LANL no date, 0520). Additionally, EM-9 has a QA program that includes written plans and administrative procedures (e.g., chain of custody, records management, quality control) that are reviewed once a year, at a minimum, and are revised as necessary.

4.0 UPDATING GUIDANCE

The ER Program's major guidance document, the IWP, is updated annually; therefore, interim guidance, as needed, is distributed to program personnel through memoranda from the Program Office and through the programmatic project leaders. When it is necessary to update procedures, the ER Program document control system, described in controlled APs, is invoked. The system provides for the revision of controlled documents at any time.

References for Annex II

EPA (US Environmental Protection Agency), March 1987. "Data Quality Objectives for Remedial Response Activities, Development Process," EPA 540/G-87/003, OSWER Directive No. 9355.0-7B, prepared by CDM Federal Programs Corporation, Washington, DC. (EPA 1987, 0086)

LANL (Los Alamos National Laboratory) no date. "Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance," Los Alamos National Laboratory Report LA-10300-M, Volumes 1 and 2, Los Alamos, New Mexico. (LANL no date, 0520)

LANL (Los Alamos National Laboratory), May 1991. "Generic Quality Assurance Project Plan for RCRA Facility Investigations for the Los Alamos National Laboratory Environmental Restoration Program," Rev. 0, Environmental Restoration Program, Los Alamos, New Mexico. (LANL 1991, 0782)

LANL (Los Alamos National Laboratory), May 1991. "Environmental Restoration Standard Operating Procedures," Vols. I, II, and III, Los Alamos, New Mexico. (LANL 1991, 0411)

LANL (Los Alamos National Laboratory), June 1991. "Los Alamos National Laboratory Quality Program Plan for Environmental Restoration Activities," Rev. 0, Los Alamos National Laboratory Report LA-UR-91-1844, Los Alamos, New Mexico. (LANL 1991, 0781)

LANL (Los Alamos National Laboratory), November 1992. "Installation Work Plan for Environmental Restoration," Revision 2, Los Alamos National Laboratory Report LA-UR-92-____, Los Alamos, New Mexico. (LANL 1992, 0768)

1.0 INTRODUCTION

This Health and Safety Program Plan of the Installation Work Plan (IWP) presents the concepts and methodologies to be used during environmental restoration activities at Los Alamos National Laboratory (the Laboratory). This Health and Safety Program Plan is an appendix to the IWP and provides an organized and rational approach for recognizing, evaluating, and controlling potential health and safety hazards that might arise from Environmental Restoration (ER) Program activities. The subsections that follow describe the program philosophy, requirements, and methods for applying the Health and Safety Program Plan to individual operable units (OUs).

1.1 Program Philosophy

The safety and health of employees, subcontractors, and visitors will be ensured through the identification, review, evaluation, and control of potential hazards associated with program activities. The Laboratory and its subcontractors are committed to limiting exposures to levels that are as low as reasonably achievable (ALARA). The Laboratory's radiation protection policy also applies ALARA principles to Laboratory-wide activities. Program personnel will be informed of known and potential hazards associated with the tasks to be performed so that they can effectively apply required safety precautions.

Maintaining a safe and healthful work environment is the responsibility of all project team members. Through a comprehensive training program, team members will be informed of hazard potentials, proper use of personal protective equipment, applicable procedural requirements, and their responsibilities for maintaining safe work environments. Trained personnel are required to adhere to all safety requirements.

Violations of environmental protection, health, and safety policies will not be tolerated. Personnel who develop a history of safety violations or who blatantly or fully violate environmental protection, safety, and health procedures will be removed from the project.

1.2 Description

Several health and safety documents are relevant to the ER Program. Consequently, it is important to understand their relationship and hierarchy.

The highest-level document is the Health and Safety (HS) Division's Hazardous Waste Operations (HAZWOP) Program. The HAZWOP Program was developed in response to Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response. This standard requires that employers develop and implement a written health and safety program for employees involved in hazardous waste operations.

The HAZWOP Program must incorporate an organizational structure, a comprehensive work plan, a site-specific health and safety plan, a health and safety training program, a medical surveillance program, the employer's standard operating procedures for health and safety, and any necessary interface between the general program and site-specific activities. Contractors and subcontractors are to be

informed of the hazards present on the site and of site emergency response procedures. The program must also address provisions for meeting excavation safety requirements. The written program is provided to contractors, employees (or their representatives), and officials with regulatory authority over the site. The HAZWOP Program also fulfills the requirements of the Environmental Protection Agency's (EPA's) Hazardous and Solid Waste Amendments (HSWA) Module of the Laboratory's Resource Conservation and Recovery Act (RCRA) permit. The HS Division has developed specific procedures to support the HAZWOP program. Other Laboratory-wide procedures are also referenced.

This Health and Safety Program Plan is the highest of three levels of health and safety document for the ER Program. The other two levels of document are derived from this program plan: the health and safety project plan, which is prepared for and is specific to each OU, and the site-specific plan, which is prepared for each site in an OU.

The purpose of the project plan is to provide information to project leaders, health and safety professionals, Laboratory program managers, and regulators about health and safety programs and procedures as they relate to individual OUs.

Each OU contains potential release sites (PRSs). Similar PRSs are aggregated for purposes of remediation. Because planning, training, employee protection, and oversight measures are different at each site, site-specific plans are developed to address this variability. The site-specific plan addresses the potential health and safety hazards of each phase of site operations and includes the requirements and procedures for employee protection. Those performing the field work are responsible for preparing a site-specific plan for each PRS or aggregate. The site-specific plan must be approved by HS Division before field work begins.

Each of these health and safety documents (the HAZWOP Program, Health and Safety Program Plan, project plan, and site-specific plan) is related. They are prepared and reviewed in a consistent manner so that they focus on their intended purpose. Figure III-1 illustrates the hierarchy of these documents.

2.0 PURPOSE

The purpose of this program plan is to provide an organized and rational approach for recognizing, evaluating, and controlling potential health and safety hazards and to provide for emergency responses as they relate to ER Program activities. The plan is derived from the HS Division's HAZWOP Program. Project and site-specific plans and standard operating procedures (SOPs) are extensions of this program plan.

3.0 SCOPE

3.1 Organizations Affected

This document governs all Laboratory divisions involved in ER Program activities, including the HS, Environmental Management (EM), and Engineering divisions, and any other division participating in the assessment or remediation of a PRS. The activities of ER Program subcontractors are also governed by this program plan.

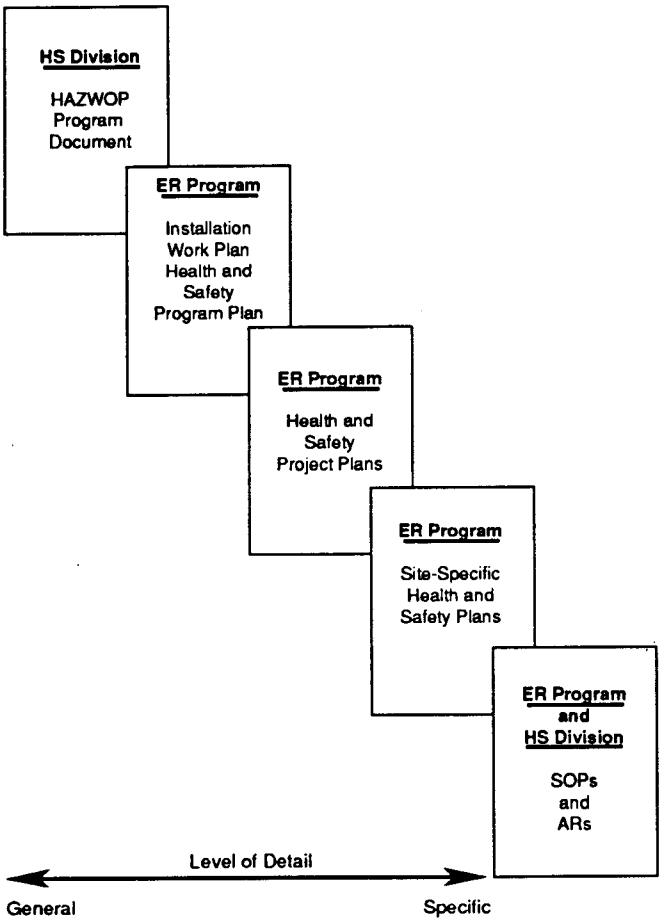

Figure III-1. Relationship of ER Program and HS Division documents.

3.2 Organizations Not Affected

Laboratory organizations and subcontractors not involved in environmental restoration activities are not affected by this program plan. Certain activities that are not conducted under the ER Program may occur at hazardous waste sites or at identified PRSs that may expose personnel to health hazards resulting from activities performed on the site. General health and safety requirements for these activities are described in the HS Division's HAZWOP Program.

3.3 Areas Affected

All PRSs are affected, including sites on land owned by the Department of Energy (DOE), Los Alamos County, the Town of Los Alamos, native Americans, and private citizens.

3.4 Areas Not Affected

Land outside the boundaries of PRSs is not affected. Waste treatment, storage, and disposal facilities are not affected.

3.5 Activities Affected

The requirements of this document apply to the following activities under the sponsorship of the ER Program:

- cleanup operations required by a governmental body, whether federal, state, or local, involving hazardous substances performed at PRSs;
- corrective actions involving cleanup operations at sites regulated under RCRA; and
- voluntary corrective actions at Laboratory PRSs.

3.6 Activities Not Affected

Operations at hazardous waste treatment, storage, and disposal facilities regulated under RCRA are not affected. Emergency response operations to control the release of hazardous substances without regard to the location of the hazard are specifically excluded.

4.0 REQUIREMENTS

The health and safety protection requirements applicable to ER Program activities at the Laboratory are set forth in DOE Orders and directives, the HAZWOP Program, and applicable federal, state, and local regulations and standards. As a matter of policy, DOE and its contractors have committed to comply with applicable OSHA regulations, specifically 29 CFR1910 and 1926.

DOE and its contractors have adopted the exposure guidelines for chemical and physical agents as given in 29 CFR 1910 and the permissible exposure limits and threshold limit values of the American Conference of Governmental Industrial Hygienists. When more than one standard exists, the most conservative value will generally be applied. DOE Order 5480.11 and the DOE's draft Radiological Control Manual establish radiological standards.

The HAZWOP Program and this program plan have been specifically developed to meet the requirements set forth in OSHA regulation 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER). The HAZWOP Program references other OSHA requirements for general industry (29 CFR 1910) and construction (29 CFR 1926) and applicable DOE orders and directives.

Laboratory Director's Policies (DPs) define the requirements for establishing formality of operations relating to health and safety quality. The DPs also require compliance with applicable federal, state, and local regulations; DOE orders and

directives; and any other agreements relating to health and safety. ER Program activities are conducted under the guiding principles of the DPs. Additional policies and requirements are presented as administrative requirements (ARs) in the Laboratory's Environmental, Safety, and Health Manual.

All regulatory requirements, standards, and guidelines for ER Program activities are incorporated in the HAZWOP Program.

5.0 RESPONSIBILITIES

The DPs and ARs set forth policy for management and employee responsibilities for health and safety. The following paragraphs are quotations from that manual and are applicable to this program.

5.1 Management Responsibility

> "The primary responsibility for employee health and safety on the job as well as for environmental protection from Laboratory operations rests with line management; this responsibility will be given first priority before Laboratory operations are approved or carried out. Supervisors are expected to recognize and anticipate potential hazards, to inform employees of risks associated with their work, to specify protective measures, and to ensure that their employees receive appropriate training. Supervisors also will establish and maintain a system to ensure that appropriate consideration is given to significant changes made in operations, procedures, materials, or equipment that could affect the safety of an activity, including environmental impact."

5.2 Employee Responsibility

> "Employees are often in the best position to evaluate health and safety risks that might result in harm to themselves and their coworkers. Therefore, Laboratory employees are responsible for observing applicable health, safety, and environment procedures; for using prescribed personal protective equipment; for promptly reporting accidents, injuries, and unsafe conditions; and for participating in required medical and biological monitoring programs."

5.3 Safety of Subcontract Personnel and Visitors

> " A safe work environment will be provided for contract personnel and visitors. This includes certain health protection services provided by HS Division. The Laboratory's health, safety, and environment rules will be enforced for everyone visiting or working at the Laboratory..."

5.4 The Project Health and Safety Team

The project health and safety team consists of members from the Radiation Protection (HS-1), Occupational Medicine (HS-2), Risk Management Support (HS-

3), Industrial Hygiene and Safety (HS-5), and Health Physics Policy and Programs (HS-12) groups. The function of the team is to ensure that ER Program activities comply with applicable Laboratory and regulatory requirements through oversight of programmatic elements and field activities.

5.5 Program Responsibilities

The ER Program manager and health and safety project leader (HSPL) are responsible for coordinating the development, review, revision, issuance, and implementation of this program plan. They will establish formality of operations that balances excellent environmental, safety, and health performance; scientific excellence; and high levels of productivity. A graded approach will be applied to each operation to ensure that the depth of detail required and the magnitude of resources expended on health and safety are commensurate with the potential hazard, the complexity of the operation, and the potential impact on health and safety.

Health and safety documents and procedures for ER Program activities are usually developed by the HS Division with input from the ER Program. The site-specific plans, which may be developed by subcontractors to the ER Program, are subject to the same review process used for plans developed by the Laboratory.

5.6 Implementation

Operable unit project leaders (OUPLs) are responsible for implementing health and safety policies and programs in the field. OUPLs must transmit this responsibility to the field team leader.

Each field team will have a field team leader and a site safety officer. The site safety officer works with the field team leader to see that work is performed safely. The field team leader does not have the authority to overrule the site safety officer on matters of health and safety. The field team leader may appeal to the HSPL.

The HSPL is the HS Division coordinator for all health and safety matters pertaining to ER Program activities. Document preparation and review, scheduling of health and safety field personnel, oversight of subcontractor health and safety programs, and conflict resolution are the responsibility of the HSPL.

The organizational structure for health and safety support of ER Program field activities is shown in Figure III-2.

6.0 RESOURCE REQUIREMENTS

Management of ER Program and health and safety activities will include assurance that work to be done has been identified, planned, scheduled, and budgeted before authorization and that there is proper control over initiation of or changes to authorized activities. ER and HS management provide for planned procurement and contracting activities and realistic contingency planning.

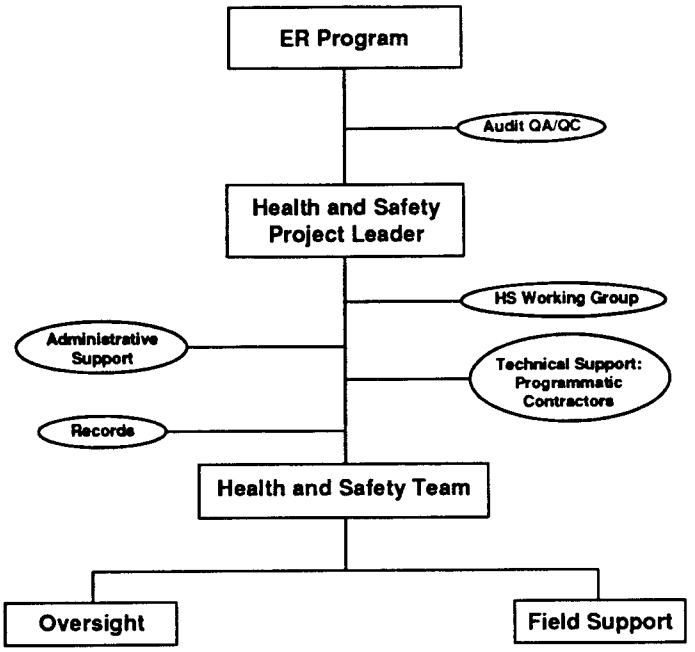

Figure III-2. Organization of health and safety support for the ER Program.

6.1 Financial Resources

The HSPL will prepare budgets and track costs related to health and safety activities for the ER Program. HS Division requests for money from the ER Program will be channeled through the HSPL. Costs for health and safety services provided directly to the ER Program (e.g., field monitoring) may be recharged to the program.

6.2 Human Resources

HS Division will provide personnel for many ER Program health and safety functions, including industrial hygienists, safety professionals, health physicists, trainers, medical professionals, health and safety technicians, and support staff. HS Division will fully support the health and safety needs of Laboratory personnel.

Subcontractors to the ER Program are expected to provide health and safety support of their personnel unless other contractual arrangements have been made. HS Division will oversee subcontractor health and safety programs and will monitor compliance with Laboratory and regulatory requirements.

HS Division may subcontract for certain health and safety services to support the ER Program, as needed, or when it is to the Laboratory's advantage.

6.3 Equipment

Personnel engaged in ER Program activities will be appropriately equipped, trained, and medically monitored to safely execute assigned duties. The Laboratory provides industrial hygiene for Laboratory employees; radionuclide-monitoring equipment, personal protective equipment, and medical supplies for examination of Laboratory employees; training materials; and computer systems.

Subcontractors to the ER Program and HS Division are expected to provide their own monitoring equipment, personal protective equipment, training materials, computer systems, and other equipment unless other contractual arrangements have been made.

6.4 Facilities

The HS Division, ER Program, and subcontractors to these organizations are expected to provide their own facilities unless other contractual arrangements have been made.

7.0 PROGRAM ELEMENTS

The elements of the HAZWOP Program are explained in detail in the HS Division HAZWOP Program document. All of the health and safety aspects required by OSHA in 29 CFR 1910.120 are covered in that document. The elements as they relate to the ER Program are described in detail in the project plan for each OU. A list of the required program elements follows:

- hazard identification,
- site control,
- personal protective equipment,
- hazard controls,
- site monitoring,
- medical surveillance and monitoring,
- bioassay,
- decontamination,
- emergencies, and
- personnel training.

Each OU has or will have a health and safety plan that addresses these program elements. Project plans will be tailored to meet the unique needs and requirements of each OU.

8.0 IMPLEMENTATION

Implementation of this health and safety program plan is a cooperative effort between the ER Program and HS Division. Together, the two organizations establish milestones and schedules.

There are several key health and safety milestones for the ER Program. The ER Program Manager, HSPL, and OUPLs are responsible for identifying milestones and tracking accomplishments. The milestones identified for the RCRA field investigation include

- reviewing, updating, and approving this program plan on an annual basis;
- preparing, reviewing, and approving the boilerplate for the project plan annually;
- preparing, reviewing, and approving the project plans for each OU;
- reviewing, updating, and approving existing project plans.
- conducting health and safety kick-off meetings with ER Program subcontractors before field work begins;
- reviewing and approving subcontractor health and safety programs;
- preparing, reviewing, and approving boilerplate for site-specific plans;
- preparing, reviewing, and approving site-specific plans;
- conducting field readiness reviews with OUPLs, field team leaders, site safety officers, and subcontractors before executing field work; and
- providing health and safety support of ER Program field activities.

As OUs move into different phases of work, the milestones will be reviewed and adjusted.

Preparing and communicating schedules are essential for timely and cost-effective completion of ER Program activities. The ER Program manager, OUPLs, and HSPL will work together to maintain a schedule for health and safety activities.

The HSPL will use Management Information System Team support and scheduling and project management tools to assist in time and resource management. Printed schedules will be made available to HS personnel on a routine and periodic basis. HS Division will use the schedule for resource planning.

OUPLs must notify the HSPL of scheduling changes and conflicts. Failure to do so could lead to delays or work stoppage. The HSPL will give scheduled events a higher priority than unscheduled, nonemergency activities.

9.0 MEASURES OF PERFORMANCE

Performance will be measured to evaluate the effectiveness of the health and safety program. The ER Program manager and HSPL will use the performance measures to manage health and safety costs and activities. Upper Laboratory management and regulators may use these data to assess program management and compliance.

9.1 Unplanned Events

The absence of unplanned events will be a positive indicator of program performance. Unplanned events include fires, explosions, chemical or radionuclide releases, motor vehicle accidents, and property damage. All unplanned events will be investigated. Findings will be reported to the ER Program manager and HSPL, who will review the findings and determine whether corrective action is necessary. Complete documentation of unplanned events will be maintained.

9.2 Audit and Assessments

A program for assessments and audits will be established and maintained to support line management knowledge and understanding of organizational performance with respect to established directives and standards. All audits and assessments will be documented, root causes of deficiencies will be identified, action plans will be prepared, and corrective actions will be tracked to completion.

DOE audits or appraisals may be conducted. The findings (or lack of findings) will be a measure of program performance. The ER Program manager and HSPL will be responsible for addressing the findings and recommendations resulting from DOE audits.

9.3 Regulatory Agency Approvals

Approval of plans and documents submitted to EPA, DOE, and NMED are a measure of program performance. The timeliness of submittals and the number of changes and resubmittals are an indicator of time management skills and quality of work.

9.4 Injury and Illness Rates

The occurrence of injuries and illness is a measure of program failure. The performance of the ER Program will be judged on all measures, not just on the number of recorded injuries and illnesses.

The goal of the ER Program and HS Division is to have no injuries or illnesses. Rates of injury and illness approaching zero are a positive measure of performance. In all likelihood, some injuries and illnesses will occur. These occurrences will be recorded on the OSHA 200 Log in accordance with Laboratory procedures.

Subcontractors will also maintain injury and illness logs in accordance with OSHA regulations. HS Division will maintain oversight of these records.

9.5 Cost Competitiveness

The ER Program manager and HSPL may develop mechanisms to compare health and safety costs. This measure of performance can help determine the value of health and safety services provided.

9.6 Productivity

The ER Program manager and HSPL may also develop methods for measuring the productivity of health and safety personnel, which can help determine the contribution of individuals and the effectiveness of resource management tools.

1.0 INTRODUCTION

This document constitutes the Records Management Program Plan for the Environmental Restoration (ER) Program at Los Alamos National Laboratory (the Laboratory), which is being implemented by the Department of Energy (DOE) and the University of California (UC). At this stage of the ER Program, certain aspects of the plan are being redefined and are considered future goals. This plan is intended to establish general guidelines for records management, including technical data sets. The specific methods and details of protecting records are implemented through quality procedures (QPs), administrative procedures (APs), standard operating procedures (SOPs), and management guidance developed in cooperation with the ER Program's quality assurance staff and the Laboratory's Records Management Program requirements document (LANL 1992, 0814).

1.1 Organization of Records Management Program Plan

This program plan is organized to interface with the body of the Installation Work Plan (IWP) and is divided into seven major sections. The introduction presents the organization, regulatory mandate, purpose, objectives, and terminology of the plan. Section 2 describes a threefold approach to records management and how it will be implemented. The Records-Processing Facility (RPF) and the Facility for Information Management, Analysis, and Display (FIMAD) are described in Section 3. Sections 4 through 7 describe how the records management program will be coordinated with the quality program, the health and safety (H&S) program, management, and community relations activities.

1.2 Regulatory Mandate

The development and implementation of this plan are mandated by the Hazardous and Solid Waste Amendments (HSWA) Module of the DOE/UC's permit to operate the Laboratory under the Resource Conservation and Recovery Act (RCRA) (EPA 1990, 0306). General requirements for data management are presented in Task II, Section B (p. 7) of the HSWA Module, but many other references to technical data are made throughout the document. The manner in which records of work performed under the permit are managed is of primary importance in ensuring the integrity and intended function of the data and documentation contained in the records submitted to the Environmental Protection Agency (EPA). The ER Program's records also include the publicly accessible documentation composing the administrative record required by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (DOE 1991, 0560; EPA 1990, 0559).

1.3 Purpose

The purposes of this Records Management Program Plan are to

- protect and manage records relevant to work conducted under the HSWA Module,
- provide an ongoing tool to support the technical efforts of UC and its ER Program contractors, and

- function as a support system for management decisions throughout the life of the program.

The plan addresses programmatic needs for all forms of technical data, program records, technical literature, and other documentation. The records are collected, organized, indexed, stored, and protected with the goal of providing efficient use and retrievability to a diverse group of users. This goal applies to both manual and automated methods of handling records. The plan enhances interactions with the local community, adjacent communities, the State of New Mexico Environment Department, EPA Region VI, the DOE, and other parties who may have an interest in the ER Program at the Laboratory.

1.4 Objective

This program plan establishes the general guidelines for managing records, regardless of their physical form or characteristics, generated and/or used by the ER Program at the Laboratory. It is important that the plan be consistently implemented to provide an auditable and legally defensible system for records management.

Coordination with other aspects of the ER Program (such as the quality and H&S programs) is important for achieving useful programwide guidelines for managing records and obtaining technical data, which, in some cases, may not be reproducible.

1.5 Terminology

It is important to use terms consistently to ensure that information is correctly conveyed to the reader of this plan. Definitions for records, technical data, information, and other terms are varied and rigorously debated. To ensure consistent use of terms, the statutory definition for "records" (44 USC 3301) is used. "Records" are defined as "...books, papers, maps, photographs, machine-readable materials, or other documentary materials, regardless of physical form or characteristics,...appropriate for preservation...because of the informational value of the data in them." Thus, the term records includes technical data and is used in this document to reflect the broader scope of protecting all ER Program records. This usage is also consistent with the General Records Schedules for environmental records, as defined by the National Archives and Records Administration (1989, 0357).

2.0 DESCRIPTION AND IMPLEMENTATION OF THE RECORDS MANAGEMENT PROGRAM

The general challenge addressed by this plan is summarized in the following question:

> "How will the ER Program's records be handled to ensure the integrity and protection of information, efficient and cost-effective access, and legal and technical defensibility?"

2.1 Plan Description

The plan incorporates a threefold approach based on records control and total commitment to quality program guidelines. This approach includes the following precepts:

- Structured work flow for records. Records control is maintained through a structured work flow and processing procedure for records.
- Use of approved procedures. Quality program requirements are met through the documented use of approved procedures by appropriately trained employees.
- Referable information base. ER Program records are submitted to an information base accessible to ER Program participants and the public while providing records protection through a documented process of change control.

2.2 Plan Implementation

2.2.1 Structured Work Flow for Records

In the recent past, records were generally maintained at the various locations of ER Program participants; therefore, no formal submittal of records was required. As quality guidelines evolved, the need for centralized protection of program records became apparent. The ER Program Office has obtained space for the RPF, which functions both as an interim repository for records while they are being processed and as a reference library for the ER Program.

2.2.1.1 Submittal of Records

Participants are required to review their records as they are generated to determine whether the information represents an ER record as defined in Section 3.1 of the Procedure for LANL ER Records Management (LANL-ER-AP-02.1). This determination can be made in two ways:

- ER records are those specifically identified in QPs, APs, SOPs, ER Program plans, and management guidance documents.
- ER records are those identified at the discretion of ER Program participants as essential to the program and required for the continued functioning and/or interests of the ER Program.

Submittal of records must be performed as required by LANL-ER-AP-02.1. All technical data, including raw data, must be submitted to the RPF for processing and eventual inclusion in the FIMAD.

Records from program administrators, analytical teams, technical teams, and contractors must be submitted to the RPF in hard copy (i.e., paper, logbooks, or

similar media) and, whenever possible, also on machine-readable electronic media. Requirements, formats, and constraints on transferring electronic records are defined in Attachment E of LANL-ER-AP-02.1.

2.2.1.2 Records Flow

Figure IV-1 is a detailed diagram of records flow in the ER Program. The model represents a top-down analysis of the general types of records, which shows how they will proceed through processing from the time of generation to final disposition.

2.2.2 Use of Approved Procedures

Only approved procedures are used for handling records. Personnel involved in processing records are trained in the use of applicable procedures.

2.2.3 Referable Information Base

Records sent to the RPF and the FIMAD provide a base of information to which all program participants can refer. They include records that document ER Program activities at the Laboratory, as well as certain records originating outside the Laboratory ER Program that have been submitted in accordance with the records management procedure.

When the originator needs to change a record in the referable information base he/she completes an ER Record Correction Form as directed in procedure LANL-ER-AP-02.1. This process ensures that ER Program participants have access to the latest version of the record.

2.3 Special Topics

2.3.1 Operable Unit Work Plans

This Records Management Program Plan is the basis for managing records for all operable units in the ER Program at the Laboratory and meets the HSWA Module requirement for a data management plan. As such, it is cited in Annex IV of each operable unit work plan. The QPs, APs, and SOPs define records requirements for technical work and typically address such matters as how to document samples, measurements, survey locations, and activity logs. Project participants protect the resulting raw data and field records until they are submitted to the RPF in accordance with LANL-ER-AP-02.1.

2.3.2 Technical Data

2.3.2.1 Data Validation

Data validation may be needed to address replicate measurements, to identify outlying values, and to explain results determined to be below detection limits. These conditions are handled in accordance with ER Program SOPs and RCRA facility

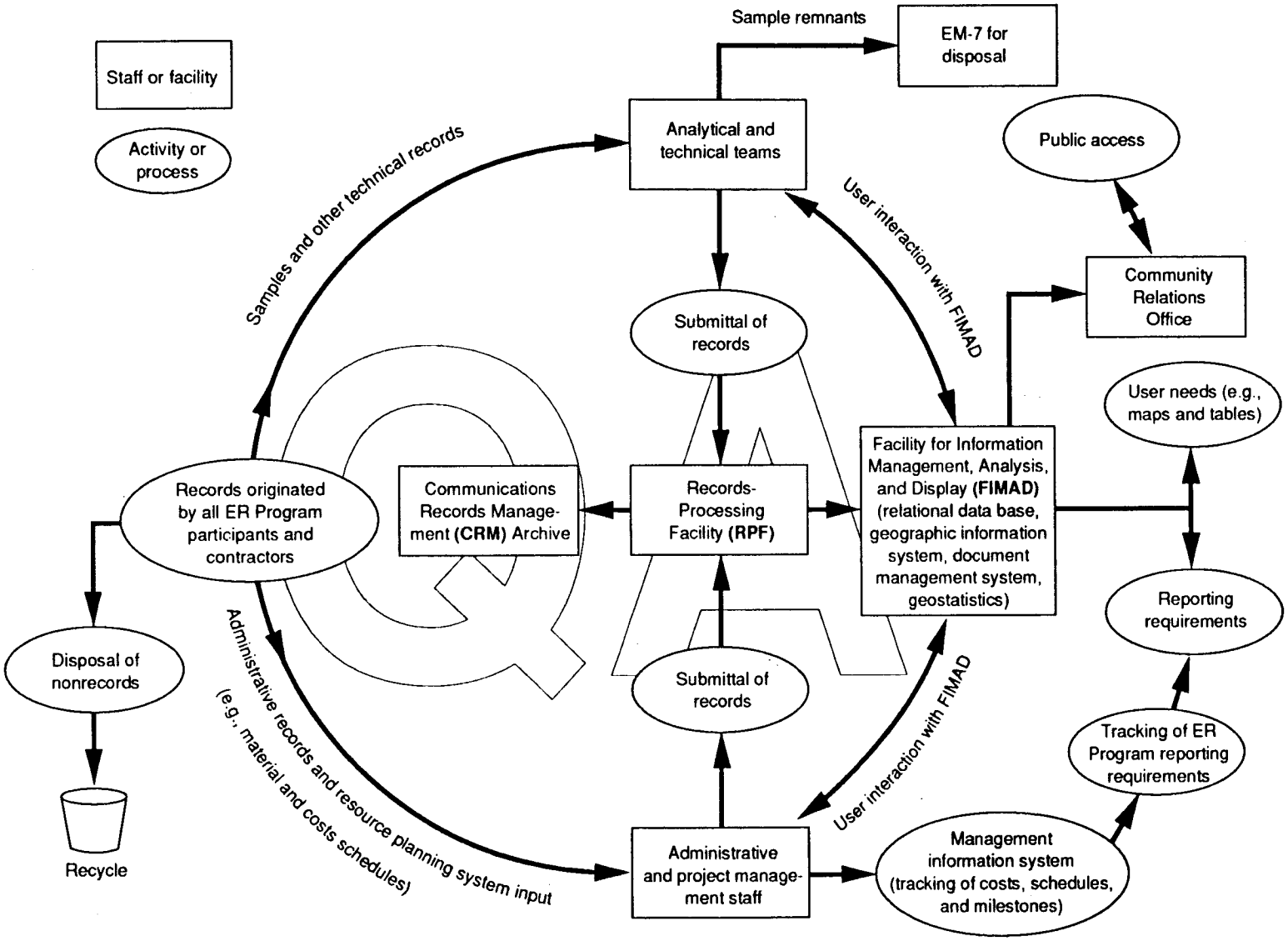

Figure IV-1. Overview of records flow in the ER Program.

investigation guidance (EPA 1989, 0088, or later revisions), if applicable. The user may develop alternate means for handling inconsistencies in data as long as the method is documented, reproducible, and technically defensible. Any reduction of data must be documented in accordance with relevant SOPs.

2.3.2.2 Data Analysis

Once technical data have been submitted, they become part of the program's referable information base (Section 2.2.3 of this plan). The FIMAD will provide the necessary capabilities for preparing tabular and two- and three-dimensional graphical displays of data, generating maps, performing statistical analyses, sorting data according to various parameters, and for meeting similar requirements as specified in ER Program SOPs and the Resource Conservation and Recovery Act (RCRA) corrective action plan (EPA 1988, 0295).

2.3.3 Records Working Group

An ad hoc team of program participants may need to meet periodically to resolve special issues related to records or specific sets of technical data. The group will comprise program participants with appropriate expertise and will be selected and activated as needed by the manager of the ER Program (or designee).

3.0 DESCRIPTION OF RECORDS MANAGEMENT PROGRAM FACILITIES

3.1 Records-Processing Facility

The RPF receives and processes ER Program records to prepare them for delivery to the FIMAD. The RPF, which is located at 2101 Trinity Drive in Los Alamos, currently houses records used in compiling site histories for potential release sites (PRSs). During processing, original records are retained at the RPF in 1-hr fire-rated equipment as defined in the Standard for the Protection of Records of the National Fire Protection Association, Inc. (1986, 0358). Either original documents or a micrographic copy, consistent with guidance obtained from the National Archives and Records Administration and the Laboratory's Records Management Program, are sent to the Laboratory's Communication and Records Management (CRM) Division or a similar long-term storage facility to ensure compliance with NQA-1 (ANSI/ASME 1989, 0018) requirements for retention and protection.

The RPF serves as a reference library that contains information that cannot or should not be entered in the FIMAD or that contains information that is accessed only occasionally (e.g., a large, multi-volume, bound report from EPA). The RPF also provides the capability to retrieve records based on a variety of parameters such as keywords, technical areas, dates, PRSs, and structures.

3.2 Facility for Information Management, Analysis, and Display

The ER Program Office has established the FIMAD in Building SM 215, TA-3, which is equipped with the hardware and software necessary to facilitate capture, display, and analysis of data. This information is readily accessible to project participants through a network of work stations.

The network will comprise "miniclusters" distributed throughout Laboratory to allow users, including ER Program contractors and the public, access to the FIMAD. Each minicluster may include graphics work stations and other necessary hardware.

3.2.1 System Capabilities

The system will be capable of executing numerous tasks using X-11 windows in a UNIX operating environment. The planned capabilities are listed below:

- geographic analysis, using the ARC/INFO/ORACLE Geographic Information System (GIS) and the GEOEAS geostatistics package;
- the ORACLE relational data base management system;
- the TOPIC document management system;
- management of video images;
- two- and three-dimensional graphics support for modeling;
- storage, compression, and conversion support for certain types of data;
- integration of various types of information; and
- automated backup and copy to a disaster recovery facility.

3.2.2 System Configuration

The development of the local area network is based on the concept of "open systems," which adhere to existing standards and protocols. Commercial software is used whenever possible to address quality program concerns about code modification and to ensure the best use of limited resources. Software quality assurance guidelines are being developed. The initial system includes RISC-based UNIX work stations, which provide a good port to the ARC/INFO/ORACLE software. This software package is a critical component of the FIMAD because it is compatible with EPA's software.

3.2.3 Configuration Management

Configuration management is being implemented as a means of accounting for, controlling, and reporting the planned and actual design of components for the FIMAD. Configuration management ensures that the latest version of the whole computer system is always approved and accessible. The end product of configuration management is formal documentation of the process of systems development to permit identification of the relevant configuration at any given period in the life of the ER Program. The documentation follows accepted practices for designing and developing information systems. Configuration management during development of FIMAD will permit flexibility in selecting system components.

3.2.4 Electronic Data Acquisition and Quality Control

ER Program participants have access to FIMAD data bases for the purposes of reviewing and updating information; however, only authorized personnel (primarily members of the FIMAD staff) may modify data. The FIMAD staff are also responsible for ensuring the quality of data originating at FIMAD (e.g., orthophoto data and the major portion of the GIS data base). Program participants who provide data to the FIMAD for electronic conversion are responsible for the accuracy of the data they submit to FIMAD; the FIMAD ensures the precision of the electronic conversion only.

3.3 Integrated Capabilities of RPF and FIMAD

The ER Program uses a hybrid approach to records management that incorporates the power and functionality of imaging technology and the reliability and precedent of micrographics.

3.3.1 Optical Disk Storage

Optical storage systems, which efficiently store enormous volumes of paper records, consist of hardware and software that convert hard-copy documents to digital form. Both government agencies and private industry are considering these systems; however, the technology presents some formidable problems relative to industry standards, legal acceptance, longevity of the medium, and costs. Optical disk storage will be used at the FIMAD to efficiently store and disseminate information via the FIMAD network. Legal issues with optical disk storage will be accommodated through the use of micrographics, as described below.

3.3.2 Microfilm

Industry standards for microfilming technology are reliable and widely accepted; therefore, this technology is used for capturing most ER Program records. The ability of the human eye to read a record on microfilm compensates for the lack of hardware standards in some components of optical disk systems. Microfilm standards and legal defensibility are well established. Microfilm may also be used to transmit color graphics information.

3.3.3 File Standards and Compatibility

The ER Program uses several different operating systems, including MS-DOS, Apple, UNIX, and VMS, which are not directly compatible. The problem of file compatibility is neither unique to the ER Program nor is it simple. This plan specifies using systems that adhere to existing standards and protocols to exchange information.

3.4 Progress in Technology

The changes in hardware and software technology are frequent and substantial and demand that attention be given to industry standards. How a product fulfills regulatory requirements for records retention, data access, and legal defensibility

influences which products are selected. Personnel assigned to operate and maintain the RPF and FIMAD keep abreast of industry trends and recommend conversions and/or modifications to the system, as necessary, to keep it a viable component of the ER Program.

Retention requirements for many records extend well beyond the typical life of systems currently used. Retention requirements are met by converting records, where practicable, to archive quality micrographic media, subject to regulatory guidelines and approval.

4.0 COORDINATION WITH THE QUALITY PROGRAM

LANL-ER-AP-02.1, which is approved by the quality project leader, is used for managing program records. The procedures and any revisions are written in accordance with LANL-ER-AP-01.1, Preparation, Review, and Approval of Administrative Procedures. The procedure is applied uniformly throughout the ER Program to achieve the objectives of this plan and to fulfill the obligations defined in the HSWA Module.

4.1 Records Protection Before Submittal

Program participants should carefully manage records, documentation, and technical data resulting from ER Program activities. The originator should protect the records in a manner commensurate with the value of the information they contain until they are submitted to the RPF in accordance with LANL-ER-AP-02.1.

4.2 Records Protection During Submittal

Records submitted to the RPF are processed in accordance with LANL-ER-AP-02.1 and other relevant procedures specific to the RPF. The processing steps are summarized below.

- The originating organization sends records to the RPF.
- While the records are being processed, a copy of an indexing form and the original record are retained at the RPF in 1-hr fire-rated equipment as defined in the Standard for the Protection of Records of the National Fire Protection Association, Inc. (National Fire Protection Association, Inc., 1986, 0358).
- When the FIMAD is fully operational, a copy of the record will be forwarded to the FIMAD.

4.3 Records Protection after Submittal

After the records are received at the RPF, the following steps are taken:

- A detailed index form is completed for each record received.
- The records processor makes a microfilm copy of both the record and the index form.

- The information from the index form is entered in the ER record data base.

- A quarterly report of records received at the RPF is sent to the originator. The original record (or a microfilm copy), which has been temporarily stored at the RPF, is forwarded to CRM Division for long-term storage. Working copies of the records are made available at the RPF and will eventually be made available through the FIMAD.

5.0 COORDINATION WITH THE HEALTH AND SAFETY PROGRAM

Certain health and safety records that result from ER Program activities are to be included in the referable information base. This information pertains to safety training and medical surveillance of each person working at a PRS. Because of the confidential nature of certain types of medical information, many records are appropriately maintained in the Occupational Medicine Group's (HS-2's) data base or by participating contractors. For convenience, training records are maintained by the appropriate Laboratory organization or by the contractors, and the ER records contain only information about the completion of training, the dates of required refresher training, and the location of the training records. The information fields to be included are

- a unique identifier for each worker,

- employer,

- dates of work at each hazardous waste site,

- dates required training was completed,

- dates of medical examinations,

- locations of training and medical examination records, and

- dates of required refresher training.

6.0 COORDINATION WITH THE ER MANAGEMENT INFORMATION SYSTEM

The ER Program's management information system monitors costs, schedules, and deliverables. The software has the capability of monitoring the reporting documents required by the ER Program, all of which are integrated in the system (as milestones or deliverables) and are disseminated to ER Program staff at regular intervals. Specific regulatory requirements for reporting, including data types and report frequency, are incorporated in the systems information. Any special reporting requirements and applicable restrictions on data type and format (e.g., cost and schedule control systems criteria or major systems acquisition) are also included.

Work breakdown structure (WBS) and activity data sheet identifiers are being integrated in the indexing plan for records as an option for querying records. Concerns about changes in the WBS and similar identifiers are legitimate and justify the decision not to use these numbers as primary indices for records.

7.0 COORDINATION WITH THE COMMUNITY RELATIONS PROGRAM

RCRA and CERCLA require that records be made available to the public. Two complementary approaches that give the public access are under way; however, because protection of the data is imperative, system security is weighted heavily in determining the optimal solution. The RPF houses the administrative record required by CERCLA. Electronic copies will be accessible through FIMAD.

7.1 Hard Copy

Hard-copy files will supplement electronic records and will be retained in a reading room accessible to the public.

7.2 Electronic Access

The best approach to providing public access to data in a manner that protects the data base has not yet been finalized; however, a computer work station or optical reading device will be used.

References for Annex IV

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1.0 INTRODUCTION

In 1987, in order to address the cleanup of sites across the nation and to ensure human and environmental health and safety at its facilities around the country, the Department of Energy (DOE) formally established the Environmental Restoration (ER) Program. The ER Program is responsible for assessing, cleaning up, decontaminating, and decommissioning sites at DOE facilities and sites formerly used by DOE and its predecessors. Los Alamos National Laboratory (the Laboratory) is operated for the DOE by the University of California (UC) and is part of the DOE's national environmental restoration program.

In accordance with the requirements of the Resource Conservation and Recovery Act (RCRA) of 1976, the ER Program at the Laboratory is designed to protect human health and the environment from exposure to releases of hazardous and mixed wastes resulting from historical treatment, storage, and disposal practices at the Laboratory. In addition, the Laboratory is committed to meeting all other applicable statutory and regulatory requirements pertaining to environmental restoration. The program is described in detail in Chapter 3 of the Installation Work Plan (IWP) for Environmental Restoration (LANL 1992, 0768).

In accordance with RCRA as amended by the Hazardous and Solid Waste Amendments (HSWA) in 1984, the State of New Mexico has issued a permit to DOE/UC to operate the Laboratory as a hazardous waste treatment and storage facility (NMEID 1989, 0595). Module VIII of the permit, issued by the Environmental Protection Agency (EPA) and known as the HSWA Module (EPA 1990, 0306), sets forth a three-step corrective action process for managing and disposing of hazardous waste.

- The RCRA facility investigation (RFI) identifies the extent of contamination at the source and the environmental pathways along which contaminants could travel to human and environmental receptors. The ER Program is currently implementing this phase of process.

- A corrective measures study (CMS) will be undertaken if the RFI indicates that corrective measures are needed. This portion of the corrective action process will evaluate the alternatives that may be used to clean up a site.

- Corrective measures implementation (CMI) is intended to perform the remedy approved by DOE and EPA after the public has had an opportunity provide input on the recommendations of the CMI.

Public participation is required only during the CMS. However, the ER Program provides opportunities for public input during each of these steps. Figure V-1 shows the corrective action process and the opportunities provided by the ER Program for public participation. Figure V-2 shows the opportunities for public input during the first phase of the corrective action process (the RFI).

The RCRA corrective action process is being applied to 603 solid waste management units (SWMUs) identified in the HSWA Module. In addition, because RCRA and HSWA do not address several issues of concern at Los Alamos, DOE/UC's ER Program addresses radioactive as well as other hazardous constituents not regulated by RCRA. The sites that contain potentially hazardous materials but no hazardous substances defined by RCRA are called areas of concern. The SWMUs

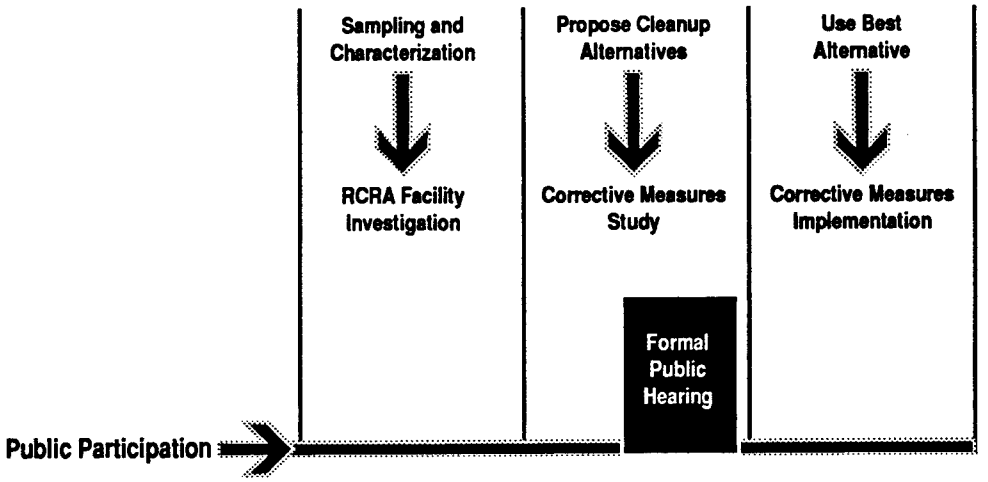

Figure V-1. Corrective action process at the Laboratory.

and areas of concern, collectively called potential release sites (PRSs), are grouped in operable units (OUs). At the Laboratory, approximately 2,000 potential release sites in 68 technical areas have been aggregated in 24 OUs.

If a potential hazard is identified during the RFI, the extent of contamination is assessed, and the ER Program can implement a voluntary accelerated cleanup known as voluntary corrective action to reduce potential hazard to human health and the environment. The public will be kept informed of voluntary corrective actions performed by the program.

The HSWA Module also requires the ER Program to prepare a community relations plan that describes opportunities for public participation in the corrective action process. This Community Relations Program Plan is designed to meet that requirement. In addition, it includes information obtained from a search of documents concerning the Laboratory's ER Program, as well as information obtained from interviews with nearby residents; representatives of organizations; and federal, state, and local officials.

Both the DOE and EPA have issued guidance documents for public participation in the ER Program, which are derived from the requirements of RCRA as amended by HSWA, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and EPA's guidance on corrective action (DOE 1991, 0798; EPA 1987, 0816; EPA 1988, EPA 1988, 0294). This plan meets those criteria and includes the general requirements of the HSWA Module, which are summarized below:

- to provide to the public opportunities to learn about technical activities and regulatory processes in the Laboratory's ER Program and to present information in a timely manner;
- to maintain a public reading room that contains all ER Program plans and reports and other information pertinent to the program;

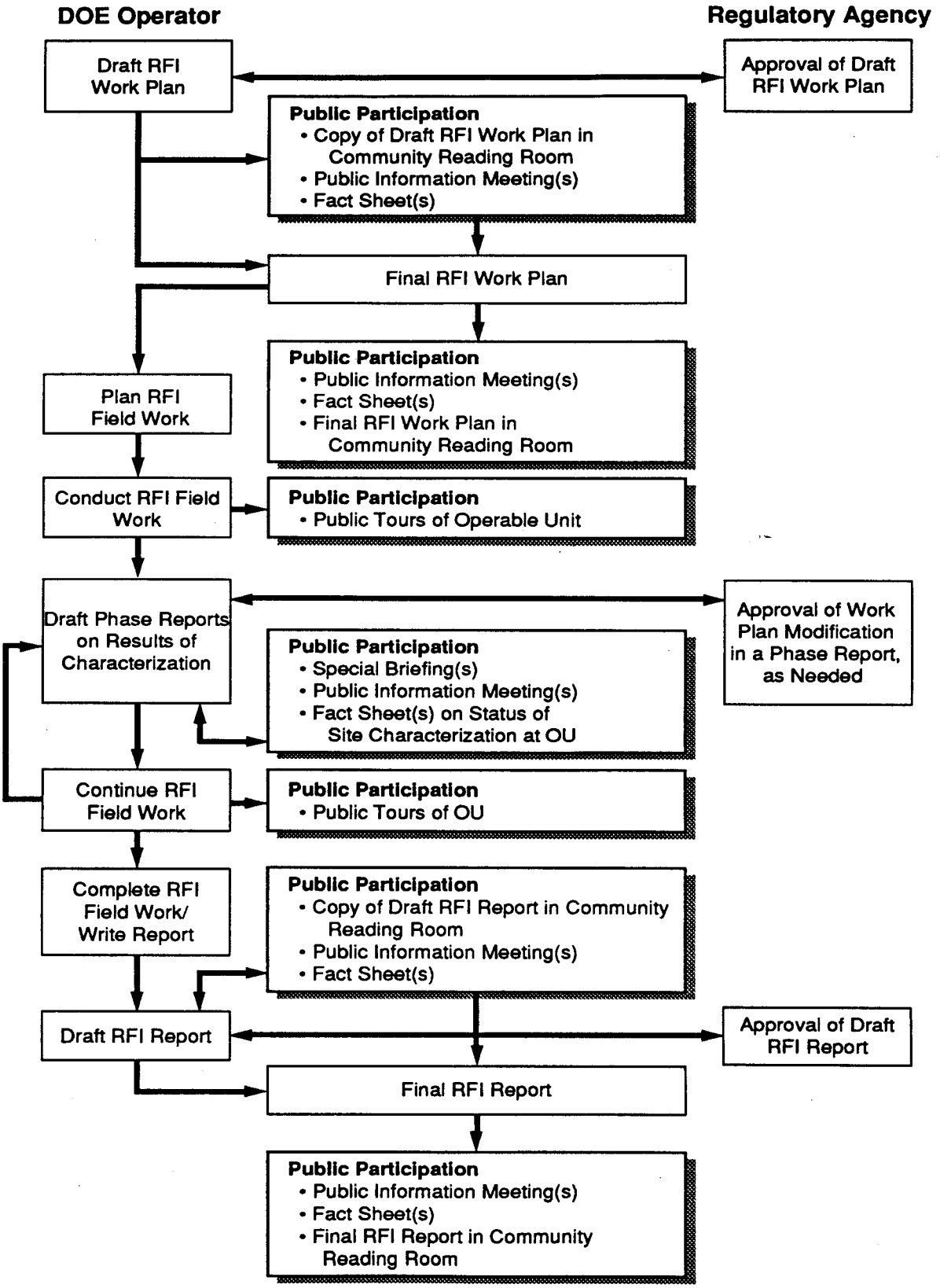

Figure V-2. Opportunities for public participation during RFI.

- to respond to community concerns about the ER Program in a manner that encourages two-way communication between interested parties and the program; and

- to afford opportunities for public input on the ER Program activities.

This plan is divided into six main sections. In addition to the brief description of the ER Program provided in this first section, Section 2 provides background of the Laboratory and the history of its environmental studies. Section 3 describes the community and its concerns about environmental issues at the Laboratory, and Section 4 contains the history of community involvement in general Laboratory and environmental issues and describes current community concerns. Section 5 summarizes the objectives of the plan, and Section 6 describes its major elements.

Because of the complexity of the Laboratory's organization and of the tasks to be performed under the ER Program, the Laboratory has designated a coordinator to assist the public in locating the information it needs. This coordinator is

Patricia Trujillo-Oviedo
Community Relations Project Leader
Environmental Restoration Program
Los Alamos National Laboratory
P. O. Box 1663, MS M314
Los Alamos, NM 87545
(505) 665-2127 or (505) 665-5000

In addition to serving as the ER Program's primary contact for the public, the community relations project leader manages the ER Program's Community Relations Program and community reading room located at 2101 Trinity Drive in Los Alamos. The community reading room will be relocated at the Museum Parke Complex at the corner of Central Avenue and 15th Street in Los Alamos when the construction of the complex is completed early in 1993.

This Community Relations Program Plan is an annex to the IWP (LANL 1992, 0768), which is available in the community reading room, the public library in Los Alamos, and the main branches of the Española and Santa Fe public libraries.

2.0 DESCRIPTION AND HISTORY OF LOS ALAMOS NATIONAL LABORTORY

2.1 Description

Historically, the principal mission of the Laboratory has been the design, development, and testing of weapons for the nation's nuclear arsenal. This effort is supported by extensive research programs in nuclear physics, hydrodynamics, conventional explosives, chemistry, metallurgy, radiochemistry, and biology. In addition to the weapons program, Laboratory personnel are involved in medium-energy physics; space nuclear systems; controlled thermonuclear fusion; laser research; environmental research; geothermal, solar, and fossil energy research; nuclear safeguards; biomedical research; and space physics. In 1992, the Laboratory expanded its mission to include development of new programs in three nationally significant areas for which it has special capabilities: health and biotechnology, environmental technologies, and industrial partnerships.

The Laboratory is located in north-central New Mexico on the Pajarito Plateau (Figure V-3), a volcanic shelf on the eastern slope of the Jemez Mountains at an approximate elevation of 7,500 ft. The Pajarito Plateau is cut by a number of steeply sloped, deeply eroded water drainage canyons, which have formed isolated, finger-like mesas running west to east. Surface water flow crossing the Laboratory is intermittent or ephemeral and reaches the Rio Grande only during significant periods of run-off from snowmelt or thunderstorms. The main aquifer lies 600 to 1,200 ft below the surface and is separated from the surface by unsaturated tuff, a volcanic ash. There is no known hydrological connection between the surface and the main aquifer from which the municipal water supply for the Laboratory and Los Alamos is obtained.

The Laboratory is situated on approximately 27,500 acres (43 mi^2) of DOE land, 24,000 acres (87%) of which are located in Los Alamos county. The location and spacing of the 35 active technical areas reflect historical development patterns, topography, and functional relationship (Figure V-4). At present, the Laboratory's onsite population (including both employees and contractors) is approximately 13,000 people, who are housed in some 1,500 buildings encompassing about 7,000,000 ft^2.

The surrounding area, including all of Los Alamos County and large portions of Sandoval, Rio Arriba, and Santa Fe counties, remains largely undeveloped, except for those areas occupied by Laboratory facilities and associated residential communities. Large tracts of land in the Jemez Mountains to the north, west, and south of the Laboratory site are held by the US Forest Service and US National Park Service. San Ildefonso Pueblo lands border the Laboratory on the east. Adjacent land ownership patterns are shown in Figure V-5.

2.2 History of Los Alamos National Laboratory

The US Army Manhattan Engineer District was established in 1942 to perform the theoretical studies and to provide the production support leading to the development of the atomic bomb. The critical research quickly progressed to the point at which a remote site for experimental work was needed, and the Army decided to move the theoretical studies and bomb development, called "Project Y," to northern New Mexico. The project acquired over 49,500 acres of land, which included the Los Alamos Ranch School for Boys, nearby homesteads, and surrounding property managed by the US Forest Service. In 1943, this land became known as the Los Alamos Site, later Los Alamos Scientific Laboratory. The Laboratory's initial mission was to develop the world's first nuclear fission weapon, a project that lasted for the duration of World War II.

Laboratory activities were first conducted in wooden buildings south of the original ranch school in what is now downtown Los Alamos. Additional buildings were constructed for research, and army-style barracks, as well as temporary and prefabricated structures, provided housing.

With the end of World War II and the growth of international competition, a national policy of maintaining pre-eminence in the field of atomic energy was established. Congress chose to sustain the Los Alamos site; the Atomic Energy Commission received control of the Laboratory from the Army and renewed the operating contract with UC. Thereafter, a major construction program was started south of Los Alamos Canyon, and most Laboratory operations were moved to the south mesa. During subsequent years, the Laboratory continued to expand at a steady rate—first under

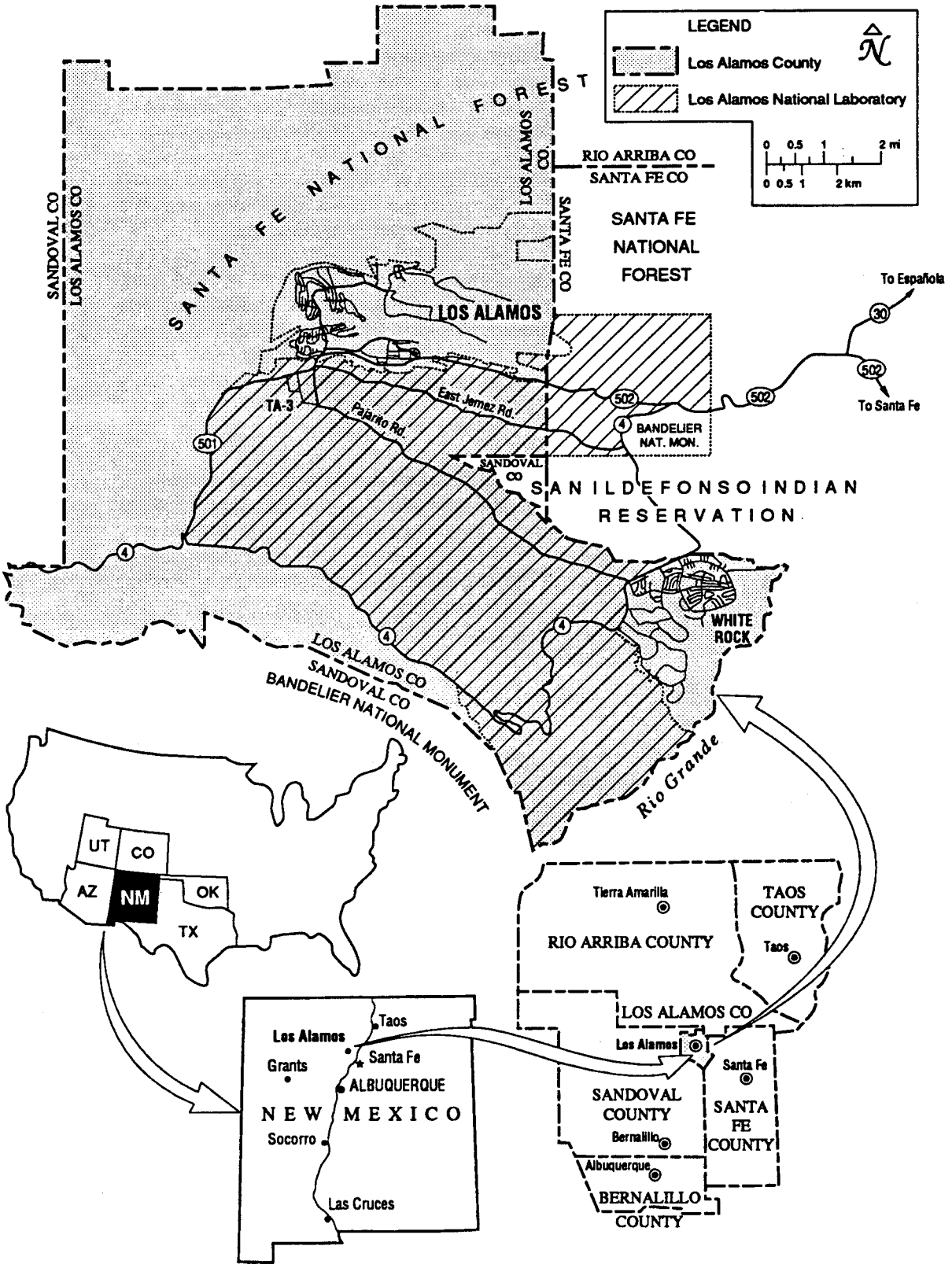

Figure V-3. Location of Los Alamos National Laboratory.

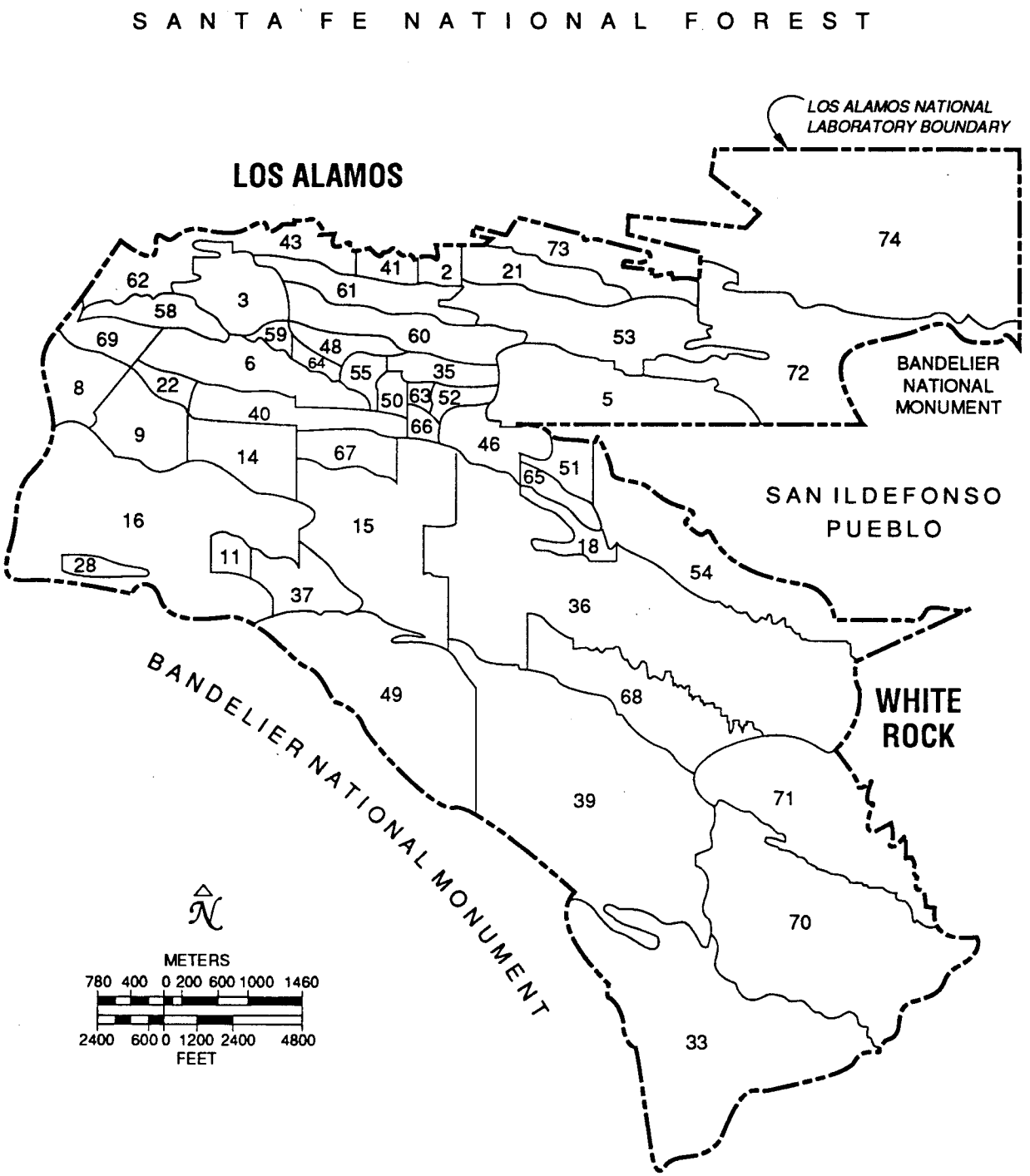

Figure V-4. Technical areas on Laboratory site.

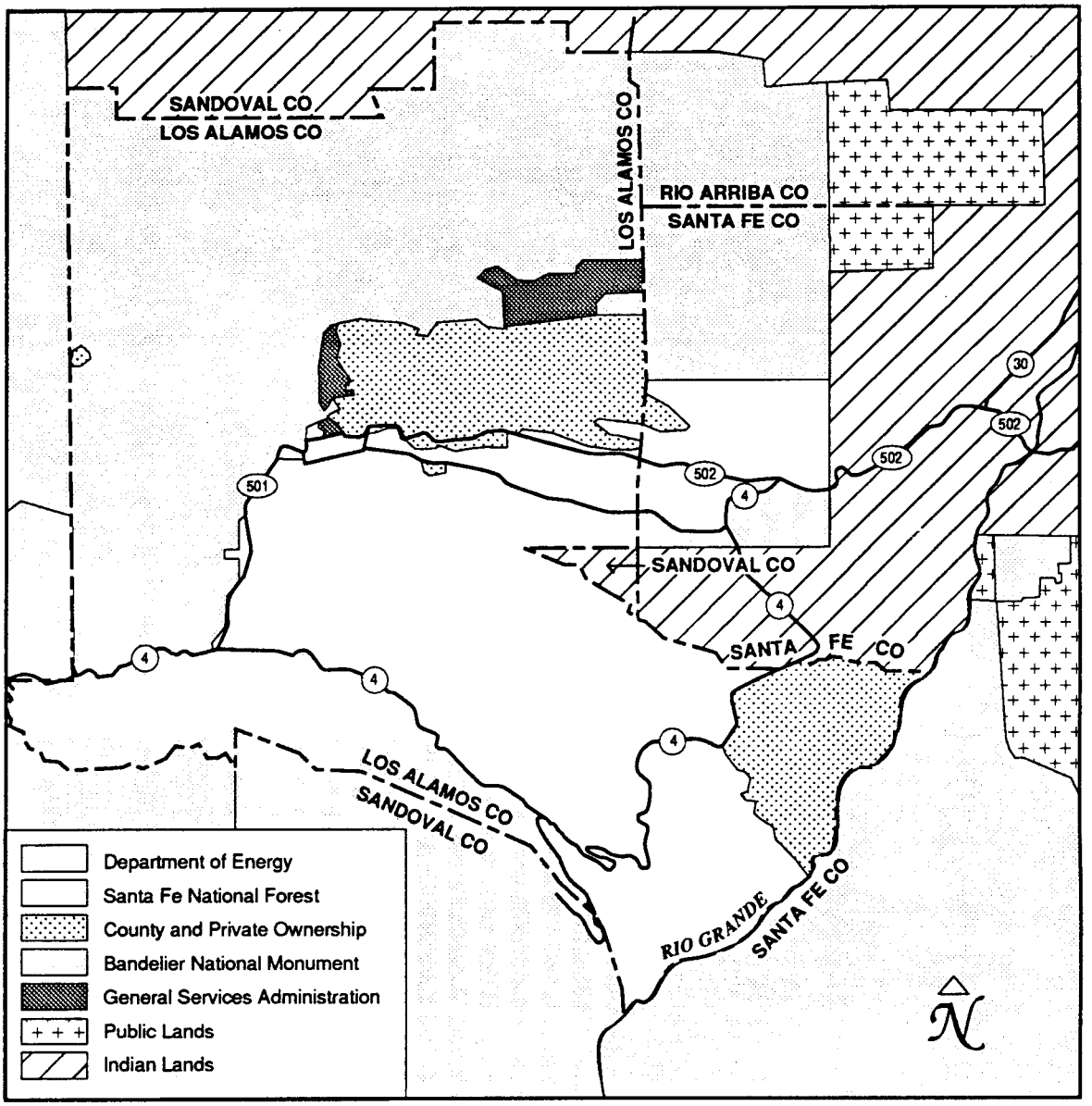

Figure V-5. Land ownership in the Los Alamos area.

the Atomic Energy Commission, later under the Energy Research and Development Administration, and today under DOE.

2.3 The Environmental Restoration Program at Los Alamos

The primary objective of the ER Program at the Laboratory is to implement the environmental assessment and remediation activities required for potential release sites (PRSs). The ultimate goal is to bring these PRSs into compliance with current environmental regulations and to do so in a manner that protects the environment and public health and safety.

From the 1950s through the late 1980s, the Laboratory identified and cleaned up several sites known to have been contaminated by Laboratory operations and testing. Under the federal regulations in existence at the time, the cleanup included removing and disposing of soil, building debris, and radioactively contaminated equipment and waste.

Since the early 1970s, the Laboratory has operated a formal environmental surveillance program that routinely samples air, water, soil, and foodstuffs throughout northern New Mexico to determine levels of contamination. The data collected under this program are published annually for distribution to the public and to local, state, and federal agencies. These data indicate that Laboratory operations do not threaten human health or the environment (Environmental Protection Group 1992, 0740).

The ER Program at the Laboratory augments the environmental surveillance program by identifying potential threats to human health and the environment caused by historic operations and by implementing efficient corrective actions that comply with applicable environmental regulations. Corrective actions include such measures as source containment to prevent contaminant migration, controls on future land use, and excavation and treatment of the contaminant source to permanently eliminate hazards to health and the environment.

The ER Program has begun to investigate both the 603 SWMUs listed by EPA in the HSWA Module and the AOCs identified by the ER Program at which an RFI should be performed. These PRSs are grouped into 24 separate OUs. Work plans for all OUs are scheduled for completion by 1995, and all CMSs are scheduled for completion by 2002. The work plans describe how the general approach provided in the IWP is tailored to each OU; the CMS will outline remediation alternatives specific to each PRS.

3.0 DESCRIPTION OF LOS ALAMOS AND REGIONAL COMMUNITIES

The Laboratory is located in north-central New Mexico, 25 mi northwest of Santa Fe. Los Alamos County, which was incorporated in 1968 and is operated by a joint city and county government, has two residential areas: the townsite, located north of Los Alamos Canyon, and White Rock, located south of the Laboratory between State Road 4 and the White Rock Canyon of the Rio Grande. The population is estimated to be 20,000. Sixty percent of the Laboratory's employees reside in Los Alamos County. The Laboratory is by far the largest employer in Los Alamos, although, in the last 10-15 years, several companies that provide support services to the Laboratory have settled in Los Alamos (LANL 1992, 0799).

Most of the remainder of the Laboratory's employees live in Santa Fe and Rio Arriba Counties, which are adjacent to Los Alamos County on the southeast and north, respectively. The City of Santa Fe is the capital of New Mexico and is a significant center of tourism. Santa Fe County is the only area of northern New Mexico in which significant population growth is expected over the next 20 years.

The area has a rich cultural history, as evidenced by the Indian ruins at Bandelier National Monument, which is located adjacent to the Laboratory's southwestern border. Numerous archaeological sites on Laboratory property have been identified and are actively protected. San Ildefonso Pueblo and Santa Clara Pueblo are located east of Los Alamos County. These pueblos are part of the Eight Northern Indian Pueblos Council, which also includes the San Juan, Taos, Picuris, Nambe, Pojoaque, and Tesuque pueblos. Cochiti Pueblo is south of the Laboratory in the Rio Grande drainage basin, and the Jemez Pueblo is located west of Los Alamos, near the Fenton Hill geothermal site.

Economic development is a significant regional concern, and the Laboratory is an important factor in the economy of northern New Mexico. As the largest employer in northern New Mexico, the Laboratory currently accounts for 38% of the jobs in that area and about 6% of the state's economic activity. Although direct employment at the Laboratory is not expected to grow, DOE's technology transfer effort is expected to increase employment opportunities by enhancing the opportunity for new industry to develop in the region (Greenwood et al. 1990, 0800).

4.0 HISTORY OF COMMUNITY INVOLVEMENT IN LABORATORY ISSUES AND CURRENT COMMUNITY CONCERNS

4.1 History of the Laboratory's Communications and Public Involvement Efforts

The Laboratory has actively communicated with the public about environmental and other issues since 1985. Some examples of these opportunities are described below.

The Laboratory has sponsored a Community Council consisting of approximately 150 members, including leaders of surrounding communities and representatives of regional organizations, DOE, and Laboratory staff. The council has met periodically since 1985 to discuss topics of concern to members.

Representatives of the Laboratory participate in the Working Group to Address Los Alamos Community Health Concerns. This group started meeting initially because of allegations that Laboratory operations may be responsible for a higher-than-average incidence of brain tumors in Los Alamos. As a result of the efforts of the working group, the DOE has earmarked monies for independent epidemiological studies to be performed for the group's use. In addition, the Laboratory has conducted epidemiological studies of the work place since 1976. Selected small groups have been followed since the 1950s.

In May 1991, the DOE conducted a two-day hearing to discuss the scope of the programmatic environmental impact statement that addresses the reorganization of the DOE's nuclear weapons complex. The hearing drew hundreds of comments from those attending. Many of the comments were directed at what DOE plans to do about the impact of existing and past releases on the environment and on the health of employees and residents of surrounding communities.

In an effort to be more proactive in dealings with the community, the Laboratory's Community Relations Group (PA-3) met individually with representatives from 27 public interest groups in northern New Mexico in early 1991 to discuss the interest groups' concerns. As an outgrowth of these contacts, the Laboratory hosted a series of dialogues to bring the groups together for further discussion (Armijo and Otway 1991, 0806; Armijo and Otway 1991, 0831; Armijo 1991, 0832).

In 1991, the Laboratory brought guest lecturers from around the nation and the world to the Laboratory and hosted roundtable discussions of such diverse topics as reconfiguration of the nuclear weapons complex, economic conversion, and agency and Laboratory credibility in matters pertaining to environmental safety and health. Laboratory representatives maintain contact with these interest groups.

To guide the Laboratory in more effective communication with New Mexicans, the Laboratory has contracted with the University of New Mexico's Institute for Public Policy to conduct quarterly random-sample surveys of New Mexicans. Although the questions asked in each survey were slightly different, New Mexicans were asked their general attitudes toward the Laboratory and toward specific Laboratory issues.

A review of three of seven quarterly reports prepared between August 1990 and February 1992 (Institute for Public Policy 1991, 0804; 1991, 0802; 1992, 0803) showed that although a majority of New Mexicans view the Laboratory favorably (consistently around 70%), increasing numbers hold unfavorable attitudes toward the Laboratory in general (10% to 18%).

A negative trend appeared in responses to questions about the Laboratory's environmental responsibility (Institute for Public Policy 1991, 0802). In general, the percentage of New Mexicans who think that the Laboratory is very environmentally responsible declined (from a high of 35% to 26%), and the percentage who viewed it as very environmentally irresponsible increased (from a low of 11% to 26%). A slight increase occurred in the percentage of those who viewed the Laboratory as neither very responsible nor very irresponsible environmentally, along with a decrease in the percentage who did not have an opinion.

At the time these surveys were being conducted, local media were reporting such controversial issues as the DOE's Waste Isolation Pilot Plant in southern New Mexico, Public Service Company of New Mexico's proposed Ojo line extension across the Jemez Mountains (believed by some to be prompted by a desire on the part of the Laboratory to augment its power supply), DOE's hearings on reconfiguring the nuclear weapons complex, DOE's proposal to move all plutonium production and testing from its other national facilities to the Laboratory, activities of the Working Group to Address Los Alamos Community Health Concerns, and ongoing environmental releases from Laboratory operations.

4.2 Environmental Restoration Program's Past Public Involvement Effort

Planning for opportunities to involve the public in the ER Program began with development of the Community Relations Program Plan published in the first IWP (LANL 1990, 0144) and the opening of the community reading room in Los Alamos in December 1990. Subsequent efforts to interact with the public include participation of ER Program staff in three meetings in Los Alamos, which were hosted by DOE to inform the public about its five-year plan for environmental restoration and waste management (DOE 1991, 0549). These meetings were held in October 1990 and March and October 1991.

In August 1991, the ER Program hosted workshops on the 1991 draft IWP (LANL 1991, 0553) in Española, Los Alamos, Santa Fe, and Taos. In September, the Laboratory and the DOE cosponsored a public meeting in Los Alamos to explain letters mailed to approximately 300 townsite residents about sampling plans to address possible contamination on their property.

In March 1992, the DOE mailed a survey to over 500 area residents and organizations asking for comments about the environmental restoration and waste management programs. Only 8% of the surveys were returned, which is too few to permit accurate inferences about community attitudes. Most respondents were either strongly in favor of or had major criticisms of DOE, the Laboratory, or the ER Program (Bellows 1992, 0805).

In May 1992, the first of what are planned to be quarterly informal public meetings sponsored by the ER Program and DOE were held in Española, Los Alamos, and Santa Fe to inform the public about sampling activities that were to begin in the townsite in June. The ER Program prepared displays, fact sheets were distributed at the meetings, and program personnel were available to meet with the public. Attendance ranged from 7 to 35 members of the public. Additionally, DOE and ER Program representatives met with owners of affected properties and briefed the Los Alamos County Council. The ER Program also provided a display and staff representatives at a June 1992 "Bridge the Gap" festival held in Los Alamos. The second round of quarterly meetings was held in mid-September in Española, Los Alamos, and Santa Fe. Public participation in those meetings doubled and, in Los Alamos, tripled.

Representatives of the ER Program have also made presentations about environmental restoration issues to groups such as the Community Council, state legislators, Rotary and Kiwanis clubs, chambers of commerce, and local neighborhood associations.

DOE and Laboratory representatives exchange information with San Ildefonso and Santa Clara pueblo leaders on the status of the ER Program and also periodically update the Eight Northern Indian Pueblos Council. Additionally, DOE has designated a staff person who acts as liaison with the pueblos and who provides pueblo members with information on environmental issues.

4.3 Current Public Involvement in Environmental Restoration Program

To gain a better understanding of how the public perceives the Laboratory and the opportunities it provides for public involvement in the ER Program, 21 interviews were conducted in June and July 1992 with local and regional regulators; representatives of federal agencies; environmental, ethnic, and community groups; Laboratory staff; local and regional elected officials; representatives of the media; and business leaders. An outside contractor, accompanied by a representative of the ER Program, posed a series of 19 questions pertaining to the ER Program and its efforts to provide opportunities for public participation. Those interviewed were also asked to comment on regional environmental issues and to evaluate media coverage of those issues.

4.3.1 Knowledge of and Concerns about the Environmental Restoration Program

Three of the persons interviewed had no knowledge of the ER Program, and two had had no contact with anyone from the Laboratory's ER Program. Six persons had had no contact at all with the ER Program. More than half had attended ER Program meetings or workshops.

When the interviewees were asked how they thought the community was affected by contamination found at PRSs, six thought that health issues were of major concern to the public, and another five said they felt that releases of contamination to the air and water were of great concern. Another five said they thought that the Laboratory was handling the sites effectively. Four or fewer mentioned the following effects (in descending order of the number of times mentioned): that the public is outraged by or distrustful of DOE and Laboratory staff and their waste management practices, that the ER Program is hurting development of the townsite, that the emotional response of some members of the public is excessive in light of the actual risk involved in restoration, that the public is not being included in the decisions in the corrective action process, that the health risks mentioned by some groups are not significant, and that the eventual restoration of the townsite will contribute to more development.

Roughly a quarter of those interviewed mentioned the high cost of the effort, the potential for development of the townsite or job opportunities, the credibility of DOE and Laboratory staff, the status of particular sites, or that they had no concerns. Three persons or fewer mentioned each of the following concerns: that the sites would not be thoroughly identified and cleaned up, that contaminated soil or debris would not be properly disposed, that the schedule was too long, that emissions from existing operations were continuing while the Laboratory concerned itself only with restoring sites contaminated in the past, that money spent on the ER Program would adversely affect funding for other operations at the Laboratory, and that the program might affect traffic flow in and around the townsite.

4.3.2 Role of the Media and the Information Repositories in Disseminating Environmental Information

The interviews revealed that only four respondents did not get their news from radio or television and that no television or radio news station was listened to more than any other. The Los Alamos *Monitor* was the most widely read newspaper (by 9 persons) and had the highest credibility about environmental issues and specifically about the Laboratory's ER Program. As many persons believed the Santa Fe *New Mexican* does a good job as believed it does a bad job in covering environmental issues. The Albuquerque *Journal* was considered to be fair in its coverage of environmental news.

Based on such a small survey, generalizations cannot be made about the population at large. Los Alamos County, however, mailed a questionnaire to over 7,000 Los Alamos households in early 1992 and received a 45% response. Over 30% of Los Alamos residents in that survey said that they read the *Monitor;* fewer than 15% and 5%, respectively, read the *Journal* and *New Mexican.* Over 10% said that they watch KOAT-TV (Channel 7) news and listen to KRSN radio news. Almost 25% said that they watched the Los Alamos cable station (PAC-8 TV) occasionally (County of Los Alamos 1992, 0801).

Almost half of those interviewed had visited the ER Program community reading room in Los Alamos, primarily to attend public meetings. Two persons who had used the reading room were critical of the information placed there. Both said that they could not find what they were looking for, and one was critical of the help he received. Over half also said that another information repository should be established in addition to the reading room in Los Alamos and information repository in Española: four persons suggested public libraries; three suggested Santa Fe. Other suggestions included DOE headquarters, New Mexico Community College, pueblos, and the Southwest Research and Information Center in Albuquerque.

4.3.3 Improving Opportunities for Public Participation in the Environmental Restoration Program

Interviewers received a variety of responses to the question of how the Laboratory can provide better communication about and opportunities for public participation in ER Program activities. The most frequent requests were for written updates and for explanations of complex, technical information in understandable language. Even many who have easy access to or receive full reports of ER Program activities desire such summaries. Almost everyone wanted to be on a mailing list for this information, as well as to be notified of meetings. Most agreed that information should be distributed when something significant occurs in the ER Program. Despite the desire of some for brief information, many still wanted to have easy access to complete information. Representatives of two community groups wanted complete, raw data or funding to conduct parallel studies to verify the Laboratory's sampling.

Both state regulators and representatives of environmental groups wanted opportunities for greater input into the activities at the Laboratory; however, the concerns of the environmental groups were not limited to the ER Program but extended to the long-range organization of the DOE's nuclear weapons complex and emissions from ongoing operations. Both groups expressed a desire to participate in roundtable discussions with DOE and Laboratory staff and with members from surrounding community groups.

The pueblos and the US Forest service requested notification by phone or by letter of any significant environmental release, particularly as it might affect their lands and people. Representatives of the media also requested immediate notice. One pueblo representative said that he did not think the DOE is living up to a signed agreement to keep the pueblos informed of new discoveries of environmental contamination.

4.3.4 Potential Public Participation in Ongoing Environmental Restoration Program Activities

All except one person said they would be willing to participate on a community advisory committee for the ER Program if one were formed. Many said, however, that they were more concerned about broader Laboratory issues.

Almost half (9 persons) said that they thought the Laboratory's efforts to involve the public were adequate. (These efforts were described to those interviewed as quarterly public meetings and additional public meetings to be held before finalization of proposed RFI, CMS, and CMI plans.) Both state regulators and members of environmental groups suggested that the Laboratory make a greater effort to use radio and television more effectively to inform the public of upcoming meetings. Representatives of both groups also suggested that the Laboratory needed to make

a sincere effort to include community groups in the process. One person suggested inviting group members to tour PRSs. Two persons affiliated with Los Alamos County suggested that the Laboratory could use PAC-8 TV to provide public briefings about activities, either by appearing at televised county council meetings or by hosting specially produced programs.

4.3.5 Other Issues Potentially Affecting Public Perception of the Laboratory and the ER Program

Almost all interviewees thought that northern New Mexicans were very sensitive to environmental issues. Three thought that public response to environmental issues depended on the issue; another three said that residents of Santa Fe and Taos were more sensitive than most.

Some of the environmental issues mentioned as attracting a lot of public attention included (in descending order): health concerns associated with past and present Laboratory emissions, air and water quality, increased plutonium production at the Laboratory, the Waste Isolation Pilot Plant, mining in the Jemez Mountains, logging on US Forest Service land, community development, transportation of hazardous materials on public roads, storage of radioactive waste at the Laboratory, the Ojo line extension project, incineration of mixed waste at the Laboratory, and expansion of the Santa Fe ski basin.

The most frequently cited nonenvironmental issue at the Laboratory was the future of the Laboratory as an area employer and the fear that cutbacks in employment would adversely affect the economy of northern New Mexico.

5.0 OBJECTIVES OF THE COMMUNITY RELATIONS PROGRAM

This Community Relations Program Plan has five objectives, which were developed after considering the information presented in Sections 2, 3, and 4 of this plan. These objectives will govern public participation throughout the corrective action process.

5.1 Objective 1—Provide the Community with Information about Environmental Restoration Program Events in a Timely Manner

The ER Program will continue to provide accurate information about its activities in a timely manner to community residents and respond to inquiries throughout the corrective action process. This information will be provided as specified by federal and state regulations and if situations arise that warrant public input into the process. Information will be disseminated to the media, Laboratory personnel, concerned residents, public interest groups, elected officials, and agency officials through fact sheets, information releases, and public notices. Additionally, the Laboratory will continue to hold informal public meetings and to maintain information repositories at the community reading room and public library in Los Alamos and at the main branches of the Española and Santa Fe public libraries. The Laboratory will work with EPA, DOE, and the New Mexico Environment Department (NMED) to coordinate community involvement efforts and information releases. These and other regulatory agencies will be kept informed of ongoing activities.

5.2 Objective 2—Establish Two-Way Communication Between Interested Parties and the Laboratory

Communication with the regional community during the RFI and subsequent steps in the corrective action process will allow the public to provide input on program-related issues, allowing the ER Program to evaluate and incorporate the public's concerns in the corrective action process. Frequent communication during this process will enable the ER Program to develop cleanup alternatives in CMS plans that respond to community concerns. In addition to holding quarterly informal public meetings, the ER Program will continue to schedule presentations and informal discussions, as well as formal meetings, with local business representatives, public interest groups, pueblo leaders, and the general public. Information releases and fact sheets will also be used to respond to community concerns and to keep the public abreast of current events.

5.3 Objective 3—Be Proactive in Providing Information to the Public and in Soliciting Participation

The ER Program will provide informal public meetings, oral and written response to queries, a speakers bureau, briefings to groups with special interests, tours, and exhibits to address issues of public concern. In addition, the ER Program will solicit suggestions on agenda items for public meetings. The public may address questions to the community relations project leader at the address and phonenumber given in Section 1 of this plan.

5.4 Objective 4—Afford Opportunities for Public Comment on Environmental Restoration Program Activities

Although the public is encouraged to provide input throughout the corrective action process, a public hearing on the proposed corrective measures alternatives for each OU, followed by a comment period of at least 30 days, will be held to receive formal comments from the community. A public hearing, followed by a comment period of 60 days, will also be scheduled in the event that a significant modification of the RCRA permit is required. This comment period will be announced at least 2 weeks in advance of the hearing date by means of display advertisements in major, general-circulation newspapers in the area and through a news release. After the close of the comment period, the DOE and the ER Program will provide a summary of public concerns, which will include responses to the concerns, and will continue communication with the public. If two or more OUs are at the same point in the corrective action process, a single public hearing may address both OUs.

5.5 Objective 5—Provide for Effective Management of Public Involvement

Implementation of the Community Relations Program Plan will continue throughout the corrective action process. Although it is the ER Program's responsibility to arrange opportunities for public participation, the ER Program will work closely with DOE, EPA, and NMED in planning these events. DOE will evaluate and monitor each event carefully to determine its effectiveness in meeting the plan's objectives. To ensure that the community's information needs are met, the ER Program will modify the plan as necessary.

6.0 ELEMENTS OF THE ENVIRONMENTAL RESTORATION PROGRAM'S COMMUNITY RELATIONS PROGRAM PLAN

The elements of the Community Relations Program Plan are discussed in this section. A description of these elements is provided in a brief narrative and is summarized in schedule format in Table V-1.

This plan outlines how the ER Program intends to provide information to and receive input from area residents. It is a dynamic document, which establishes ER Program policy on how to most effectively communicate information about the progress of the ER Program. It has been revised once since the first edition of the IWP in 1990 and will be updated as necessary during the corrective action process and when the corrective measures design (implementation) phase begins.

6.1 Public Notification

6.1.1 Mailing Lists

The ER Program Office and the ER Program's Community Relations Office maintain a mailing list of individuals and groups interested in the Laboratory's ER Program. Federal, state, and local officials, regional media, community and environmental groups, and interested area residents are included. Those on this list receive the *Environmental Update* publication, public meeting notices, and other announcements pertaining to the ER Program.

6.1.2 Public Notices

Once an RFI report or CMS for any of the OUs at the Laboratory has been distributed to DOE, EPA, and NMED, the community is invited to provide input. A public notice, which is a paid advertisement in the main section of a newspaper of general circulation, is published in the Los Alamos *Monitor*, Santa Fe *New Mexican*, *Albuquerque Journal North*, the Española *Rio Grande Sun*, and in other newspapers, as appropriate. Public notices are also used to announce meetings, public comment periods, and completion of major milestones in the ER Program. Although news releases and public service announcements are also sent to newspapers and radio and television stations throughout northern New Mexico, the ER Program also uses paid notices to ensure that the information appears in print. In addition, an announcement is mailed to those on the ER Program mailing list.

The public has at least 30 days to review the documents (located at the community reading room and the public library in Los Alamos and at the information repositories in the main branches of the public libraries in Española and Santa Fe) and to send comments to the ER Program, DOE, EPA, and NMED at addresses provided in the public notice.

6.1.3 News Releases

News releases are written and issued to local news media and those on the ER Program mailing list when a technical milestone in the corrective action process has begun or has been completed and to announce a public meeting or issuance of a new report.

TABLE V-1

RELATIONSHIP OF PUBLIC INVOLVEMENT ACTIVITIES TO THE ENVIRONMENTAL RESTORATION PROGRAM TECHNICAL MILESTONES FOR EACH OPERABLE UNIT AT THE LABORATORY

Public Involvement Activity	Environmental Restoration Program Technical Milestones											
	RCRA Facility Assessment (RFA)		RCRA Facility Investigation (RFI)			Corrective Measures Study (CMS)			Corrective Measures Implementation (CMI)			
		Interim Measure(1)	Work Plan	During RFI	Release of RFI Report	During CMS	Release of CMS	Selection of Measure	Begin Design	During Design	Completion of Design	Implementation
Draft Public Involvement Plan		X	X									
Communications Training			X (Ongoing as Needed)									
Environmental Activities Newsletter			X (Ongoing)									
Fact Sheets			X		X		X				X	X
Information Meetings and Open Houses				X (Held Quarterly As Needed)								
Information Repositories and Community Reading Room			X (Information is Included as Available)									
Mailing Lists			X (Ongoing)									
News Releases (As needed throughout the process)	X	X	X	X	X		X				X	X
Participation in Public Forums			X (Ongoing)									
Public Comment Period							X					
Public Hearings					X	X	X					
Public Notices and Public Service Announcements (PSAs)			X (Ongoing)							X		
Supporting Information Meetings and Open Houses								X	X	X		
Supporting Public Hearings												
Response to Inquiries			X (Ongoing)									
Responsiveness Summary to Public Hearings*								X				
Speakers Bureau			X (Ongoing)									
Special Briefings, Tours, and Workshops			X (Ongoing)									
Spokesperson Identification	X (Ongoing)											
Timely Notification	X (Ongoing)											
Update Public Involvement Plan*			X			X			X			

*May be performed as necessary throughout the corrective action.

In addition to topics addressed in news releases issued by the ER Program, reporters often request that the Laboratory provide information on special topics. Media requests are handled through the community relations project leader at the ER Program, with assistance from the Public Affairs Office, and requests for media interviews or tours of ER Program sites are honored as quickly as possible.

6.1.4 Special Notices

Special notices are issued in three situations.

6.1.4.1 Notification of Offsite Releases

Part D, No. 8, of the HSWA Module provides for "procedures for immediate notification of the San Ildefonso Pueblo or other affected parties in case of a newly discovered offsite release that could impact them." Any new releases from existing, identified PRSs are brought to the attention of the ER Program, which works with the DOE's tribal liaison to coordinate notification of the potentially affected parties.

6.1.4.2 Interim Measure Notification

In the event that the investigation of an OU indicates the need for immediate remedial action, an interim measure will be taken. The community relations project leader, together with the OU project leader, will evaluate the types of communications necessary and will develop a communications plan for each interim measure. At a minimum, a news release about the interim measure will be sent to all local media. The community relations project leader will also arrange briefings upon request.

6.1.4.3 Notification of Voluntary Corrective Action

Voluntary corrective action documentation will be submitted to EPA in quarterly technical progress reports and other appropriate documentation. When the voluntary corrective action serves as the final remedy, a request for a formal permit modification for no further action will be made. These issues will be discussed in quarterly public meetings.

6.2 Public Hearings

A public hearing will be held when the final draft of each RFI work plan and each CMS plan have been completed to enable the public to provide input to these documents. At the hearing following the release of the RFI work plan, the ER Program will explain the results of the investigations, and, at the hearing following the release of the CMS plan, the cleanup alternatives will be explained. Other public hearings to present RFI and CMS findings will be scheduled as necessary. In the event a significant permit modification is necessary, EPA will conduct formal public hearings. Opportunities for public input will be provided during and after each public hearing.

The DOE is required to prepare a responsiveness summary after the public hearings on the RFI work plan and CMS and subsequent comment period have ended. The responsiveness summary consists of a transcript of the hearing and all comments submitted during the comment period, together with DOE's responses. Responsive-

ness summaries are placed in the community reading room and in the information repositories for public review.

6.3 Methods of Distributing General Information

6.3.1 Community Reading Room and Information Repositories

The ER Program maintains a community reading room and three information repositories to provide public access to technical documents, reports, and related communications. The information is managed by the community relations project leader with support from the ER Program's Records-Processing Facility.

The main location for these documents is in the community reading room located in Los Alamos, and secondary locations are at the public library in Los Alamos and the main branches of the Española and Santa Fe public libraries. Locations and hours are listed in Table V-2.

TABLE V-2

LOCATIONS AND HOURS OF ENVIRONMENTAL RESTORATION PROGRAM INFORMATION REPOSITORIES

Location	Address and Phone Number	Hours
Community Reading Room	1201 Trinity Drive[a] Los Alamos, NM 87545 (505) 665-2127	Monday-Friday: 9:00 am-4:00 pm[b]
Española Public Library	314A Onate Street (505) 753-3860 Española, NM 87532	Monday, Tuesday, Thursday, and Friday: 10:00 am-6:00 pm Wednesday: 10:00 am-8:00 pm Saturday: 10:00 am-1:00 pm
Mesa Public Library	1742 Central Los Alamos, NM 87544 (505) 662-8250	Monday-Thursday: 10:00 am-9:00 pm Friday: 10:00 am-6:00 pm Saturday: 9:00 am-5:00 pm Sunday: 11:00 am-5:00 pm
Santa Fe Public Library	145 Washington Avenue Santa Fe, NM 87501 (505) 984-6780	Monday-Thursday: 10:00 am-9:00 pm Friday-Saturday: 10:00 am-6:00 pm Sunday: 1:00-5:00 pm

a. The ER Program plans to relocate the reading room in early 1993 to the Museum Parke Office Complex at 15th Street and Central, next to the new Bradbury Science Museum.

b. Arrangements to use the reading room at other times can be made by calling (505) 665-5000 or 665-2127.

6.3.2 Fact Sheets and Quarterly Updates

The ER Program prepares fact sheets and, as necessary quarterly updates on the OUs, as well as and quarterly updates on the ER Program, which are available at the community reading room and in the information repositories. All fact sheets and information releases include the address and telephone number of the community relations project leader.

An update will be published quarterly by the ER Program Office to provide information to anyone interested in the progress of the ER Program. In addition to providing general information about the ER Program, upcoming meetings and related events will be announced. Those wishing to be added to the mailing list for the update should contact the community relations project leader at the Laboratory at (505) 665-2127 or 665-5000.

6.3.3 Informal Public Meetings

Informal public meetings are scheduled quarterly and if an ER Program action generates significant public inquiry or concern. ER Program staff and the appropriate OU project leaders and technical experts are present at each meeting to provide up-to-date information, to respond to technical questions in their field, and to meet individually with members of the public. Although informal public meetings are scheduled quarterly, often individuals and groups want an update on specific elements of the program. The public is invited to write or call the Laboratory community relations project leader at any time during the corrective action process to schedule a meeting or presentation. DOE, EPA, and NMED officials are informed of plans for these meetings.

6.3.4 Special Briefings, Tours, and Exhibits

Before each quarterly meeting or public hearing, a representative from either DOE or the ER Program will offer to brief the Los Alamos County Council, whose meetings are usually aired on the local cable station, PAC-8.

Site tours are also offered to public groups and individuals who wish to observe the activities and progress of the project. Depending on public need and available Laboratory resources, these tours are scheduled either at a specified time for large groups or as requested by individuals.

When a public group identifies a specific concern or a highly complex technical issue important to that group that could be too technically detailed or too narrowly focused for a general public audience, a special briefing or workshop, to be held in Los Alamos or in the group's local community, may be scheduled. Technical personnel from the ER Program who have expertise in the field(s) of concern to the group will be available to allow an exchange of information in an informal setting.

Exhibits about various aspects of the program are kept on file and can be set up at conferences, community events, fairs, or other locations to raise the awareness of the public about the ER Program.

6.3.5 Speakers Bureau

The Laboratory's speakers bureau provides speakers to community organizations to address topics about the Laboratory, including the ER Program. The community relations project leader identifies and calls upon appropriate ER Program staff to make presentations to the public. Requests for speakers may be made through the community relations project leader or the speakers bureau coordinator in PA-3, (505) 665-5000.

6.3.6 Participation in Public Forums

If a request is made in a meeting or forum for discussion of a topic related to the ER Program, the community relations project leader will provide a speaker for the group raising the issue.

6.3.7 Communications Training

Because information pertaining to the ER Program is complex, the community relations project leader coordinates and participates in training programs for key personnel so that they are able to communicate complex technical issues clearly.

6.3.8 Responding to Inquiries

The ER Program gives high priority to responding to public inquiries. The community relations project leader works closely with Laboratory management, the Laboratory's Public Affairs Office, and ER Program staff to ensure that timely and accurate information is provided. The community relations project leader will coordinate responses to detailed and complex technical inquiries with the appropriate technical experts in the ER Program.

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Metric to English Conversion Table

APPROXIMATE CONVERSION FACTORS FOR SELECTED SI (METRIC) UNITS

Multiply SI (Metric) Unit	by	To Obtain US Customary Unit
Cubic meters (m^3)	35	Cubic feet (ft^3)
Centimeters (cm)	0.39	Inches (in.) meters
Meters (m)	3.3	Feet (ft)
Kilometers (km)	0.62	Miles (mi)
Square kilometers (km^2)	0.39	Square miles (mi^2)
Hectares (ha)	2.5	Acres
Liters (L)	0.26	Gallons (gal.)
Grams (g)	0.035	Ounces (oz)
Kilograms (kg)	2.2	Pounds (lb)
Micrograms per gram (mg/g)	1	Parts per million (ppm)
Milligrams per liter (mg/L)	1	Parts per million (ppm)
Celsius (°C)	9/5 + 32	Fahrenheit (°F)

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■ APPENDIX A

Descriptions of Technical Areas at Los Alamos National Laboratory

DESCRIPTIONS OF TECHNICAL AREAS AT LOS ALAMOS NATIONAL LABORATORY

The locations of the 49 technical areas (TAs) operated by Los Alamos National Laboratory (the Laboratory) in Los Alamos County are shown in Chapter 2, Figure 2-2. The main programs conducted at each of the active, developed areas are listed in this appendix.

TA-2, Omega Site

The Omega West Reactor, an 8-MW nuclear research reactor, is located at TA-2. The reactor provides neutrons for fundamental studies in nuclear physics and associated fields.

TA-3, South Mesa Site

The main technical area of the Laboratory, TA-3 includes the Administration Building in which the Director's office and other administrative offices and laboratories for several divisions are located. Other buildings house the central computing facility, administrative offices, materials division, science museum, chemistry and materials science laboratories, physics laboratories, technical shops, cryogenics laboratories, a Van de Graaff accelerator, and the main cafeteria.

TA-6, Two-Mile Mesa South Site

Two-Mile Mesa Site is one of three sites (TA-22 and TA-40 are the other two) used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research conducted at this site includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-8, GT Site (or Anchor Site West)

Nondestructive testing is conducted at this site for the entire Laboratory. The test facilities maintain capability in all modern nondestructive testing techniques to ensure the quality of material ranging from test weapons components to high-pressure dies and molds. The principal activities involve radiographic techniques (using x-ray machines to 1,000,000 V and a 24-MeV betatron), radioactive isotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

TA-9, Anchor Site East

At this site, the physical properties and feasibility of fabricating explosives are explored, and new organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K Site

The facilities at this site test explosive components and systems under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q Site

This firing site is used for running various tests on relatively small explosive charges and for determining the impact of fragments.

TA-15, R Site

This site is the home of PHERMEX, a multiple-cavity electron accelerator capable of producing a very large flux of x rays for certain weapons development problems and tests. The site is also used for investigating how weapons function and systems behave in nonnuclear tests, principally by electronic recording means.

TA-16, S Site

The facilities at this site house the development, engineering design, pilot production, and environmental testing of nuclear weapons warhead systems. Other functions include stockpile production liaison; development and testing of high explosives, plastics, and adhesives; and research on process development for manufacture of items using these and other materials.

TA-18, Pajarito Laboratory Site

The fundamental behavior of nuclear chain reactions with simple, low-power reactors called critical assemblies is studied here in buildings known as kivas. Experiments are operated by remote control and are observed by closed-circuit television. The reactors are used primarily to provide a controlled means of assembling a critical amount of fissionable materials to study the effects of various shapes, sizes, and configurations. The machines are also used to produce large quantities of fission neutrons for experimental purposes.

TA-21, DP Site

This site has two primary research areas: DP-West, a chemistry research facility, and DP-East, a research site for high-temperature chemistry and tritium.

TA-22, TD Site

See TA-6.

TA-28, Magazine Area A

The Laboratory uses this site as one of two storage areas for explosives.

TA-33, HP Site

A major high-pressure tritium-handling facility is located at HP Site. Laboratory and office space for the Geosciences Division's hot dry rock geothermal project is also located at this site.

TA-35, Ten Site

Nuclear safeguards research and development conducted here are concerned with nondestructive techniques for detecting, identifying, and analyzing fissionable isotopes. Research in reactor safety and laser fusion also occurs at this site.

TA-36, Kappa Site

Various explosive phenomena, such as detonation velocity, are investigated at Kappa Site.

TA-37, Magazine Area C

See TA-28.

TA-39, Ancho Canyon Site

Nonnuclear weapons behavior is studied here, primarily by photographic techniques. Various phenomenological aspects of explosives, interactions of explosives, and explosions involving other materials are also investigated at this site.

TA-40, DF Site

See TA-6.

TA-41, W Site

Personnel at this site are engaged primarily in engineering design and development of nuclear components, including fabrications and evaluation of test materials for weapons.

TA-43, Health Research Laboratory

The Biomedical Research Group does research here in cellular radiobiology, biophysics, mammalian radiobiology, and mammalian metabolism. A large medical library, special counters used to measure radioactivity in humans and animals, and quarters for dogs, mice, and monkeys are also located in this building.

TA-46, WA Site

Applications for photochemistry, which include development of technology for laser isotope separation and laser enhancement of chemical processes, are investigated here. Solar energy research, particularly in the area of passive solar heating for residences, also occurs at this site.

TA-48, Radiochemistry Site

Using analytical and physical chemistry, scientists and technicians at this site study the nuclear properties of radioactive materials. Radioactive substances are measured in hot cells, which permit remote handling of radioactive materials.

TA-49, Frijoles Mesa

Frijoles Mesa has been used primarily as the site of underground hydronuclear experiments, conducted in 1960 and 1961, and as a buffer zone for nearby firing sites. The site is currently used for high-power microwave research and for training the Laboratory's hazardous devices team.

TA-50, Waste Management Site

Personnel at this site have responsibility for treating and disposing of most industrial liquid waste received from Laboratory technical areas, for developing improved methods of solid waste treatment, and for containing the radioactive materials removed by treatment. Radioactive liquid waste from most technical areas is piped to this site for treatment.

TA-51, Environmental Research Site

Experiments conducted at this facility explore waste cover and stabilization alternatives, land reclamation, contaminant movement, and ecology.

TA-52, Reactor Development Site

A wide variety of activities related to nuclear reactor performance and safety is conducted at this site.

TA-53, Meson Physics Facility

The Los Alamos Meson Physics Facility, a linear particle accelerator, is used to conduct research in areas of basic physics, cancer treatment, materials studies, and isotope production. The Los Alamos Neutron Scattering Center and the proton storage ring are also located on this site.

TA-54, Waste Disposal Site

Solid radioactive and toxic wastes that meet regulatory acceptance criteria are disposed at this site.

TA-55, Plutonium-Processing Facilities

These facilities process plutonium and house research in plutonium metallurgy.

TA-57, Fenton Hill Site

The Laboratory's hot dry rock geothermal project is located at Fenton Hill, where scientists are studying the possibility of producing energy by circulating water through hot, dry rock located hundreds of meters below the earth's surface. After the water is heated, it is brought to the surface to drive electric generators.

TA-59, Environment, Safety, and Health Site

Occupational health and environmental science activities are conducted at this site.

TA-60, East Jemez Road

This area contains physical support facilities for the Laboratory, including the existing landfill.

TA-63, Pajarito Road Service Site

This area contains physical support facilities operated by World Services, Inc.

TA-74, Los Alamos Airport

This area contains the DOE-owned airport that serves the Laboratory.

■ APPENDIX B

Los Alamos National Laboratory Waste Minimization and Pollution Prevention Awareness Plan

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TITLE: Los Alamos National Laboratory Waste Minimization and Pollution Prevention Awarenss Plan

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Environmental Management Division

SUBMITTED TO:

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Los Alamos National Laboratory Waste Minimization and Pollution Prevention Awarenss Plan

by
Hilary Noskin

June 1992

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EXECUTIVE SUMMARY

The Los Alamos National Laboratory (LANL) Waste Minimization and Pollution Prevention Awareness Plan is prepared by the Waste Minimization Program Office (WMPO) in the Environmental Management Division Office (EM-DO). This plan is required by Federal, State and DOE regulations, including DOE Orders 5400.1, 5400.3, and 5820.2A.

The LANL Waste Minimization and Pollution Prevention Awareness Plan establishes the LANL Waste Minimization and Pollution Prevention Awareness Program. This plan discusses those activities and methods to reduce waste generation at LANL, and incorporates the objectives of the WMPO to promote an effective and comprehensive program at LANL.

This plan is based on a format for Waste Minimization Plans issued complex-wide through the Implementation Guidance for DOE Order 5400.1. Therefore, pages 5 through 21 contain general information that is standard across the complex. Specific information, directly related to LANL operations, is provided in Appendixes A, B, C, and D.

I. INTRODUCTION/BACKGROUND

A. Purpose. The purpose of this plan is to establish the Los Alamos National Laboratory (LANL) Waste Minimization and Pollution Prevention Awareness Program. The plan discusses those activities and methods that will be employed to reduce the quantity and toxicity of waste generated at the site. This plan will be in accordance with all federal, state, and Department of Energy (DOE) requirements. The Pollution Prevention Awareness Program is included with the Waste Minimization Program as permitted by DOE Order 5400.1. Major requirements are discussed in paragraph C.

B. Scope. A waste minimization program is an organized, comprehensive, and continual effort to systematically reduce waste generation. The Waste Minimization and Pollution Prevention Awareness Program is designed to eliminate or minimize pollutant releases to environmental media from all aspects of the Laboratory's operations. Included are methods of reducing hazardous chemical waste, transuranic waste, low-level radioactive waste, radioactive liquid waste, mixed waste, and sanitary/industrial waste. This program offers increased protection of public health and the environment and yields the following additional benefits:

1. Reduces waste management and compliance costs,

2. Reduces resource usage,

3. Improves product yields,

4. Reduces or eliminates inventories and releases of hazardous chemicals reportable under the Emergency Planning and Community Right-to-Know Act, and

5. Reduces or eliminates civil and criminal liabilities under environmental laws.

The program reflects the goals and policies for waste minimization of the Laboratory, and represents an ongoing effort to make pollution prevention/waste minimization part of the Laboratory's operating philosophy.

The objective of the waste reduction effort at the Laboratory is to identify ways that minimize the quantity of waste being generated. The methods that the Laboratory uses includes the following:

1. Process modification and materials substitution to reduce or eliminate waste at the source;

2. General principals of abatement, housekeeping and segregation, and reuse and recycling to minimize the waste generated;

3. Education, training, communication, technical bulletins, procedure, and policy changes, and publicity to implement change;

4. Specific principles of purchasing discipline and procedure reviews to prevent problems;

5. Information data bases to identify solutions to the problems; and

6. Design reviews, waste tracking, prioritization, and Waste Management Coordinator input to identify and anticipate problems in advance.

The plan is a reference tool and guidance document for managers, operations personnel, and support staff. It contains the policy, objectives, strategy, and support activities of the Waste Minimization and Pollution Prevention Awareness Program. Waste minimization goals, the development of waste generation baseline information through waste minimization assessments, and a process for continual evaluation of the program are primary elements of the plan. Various waste minimization techniques will be implemented with the support of employee training and awareness programs to reduce waste and still meet the requirements for quality, productivity, safety, and environmental compliance.

This plan applies to all LANL operations and associated support operations. This plan will be reviewed annually and revised a minimum of every three years.

The Plan has been distributed to affected employees and site contractors, and the policy, goals, objectives, and strategy of the plan have been explained to all employees.

C. Legal and policy Background. The Resource Conservation and Recovery Act (RCRA) requires hazardous waste generators to establish a program to reduce the volume or toxicity of waste to the degree determined by the waste generator to be "economically practicable." Hazardous waste generators must certify in their waste manifests that this requirement has been fulfilled. Generators must also identify in their biennial reports to the Environmental Protection Agency (EPA) the efforts undertaken during the year to reduce the volume and toxicity of waste generated and the changes in volume and toxicity actually achieved. Waste generators also have the option to report waste minimization results in their

annual submission of toxic chemicals release inventories to EPA. RCRA reauthorization, new toxic release reporting, and the Pollution Prevention Act of 1990 make the federal requirements for waste minimization more stringent. In addition, the State of New Mexico is a regulatory authority and has primacy over RCRA regulations. This plan will comply with all federal and state reporting requirements.

DOE Orders 5400.1, 5400.3, and 5820.2A mandate that the management of radioactive wastes and other pollutants shall be accomplished in a manner that minimizes the generation of such wastes.

DOE Order 5400.1 establishes environmental protection program requirements and responsibilities for ensuring compliance with environmental protection laws. The order requires the establishment of a Waste Minimization Program "that will contain goals for minimizing the volume and toxicity of all wastes that are generated" and a Pollution Prevention Awareness Program. The Waste Minimization Program and the Pollution Prevention Awareness Programs are to be established through implementation plans. The implementing guidance permits the two programs and implementation plans to be consolidated.

DOE Order 5400.3 establishes DOE hazardous and radioactive mixed waste policies and requirements and implements the requirements of RCRA within the framework of the environmental programs established under DOE Order 5400.1. The order states that it is DOE policy to "implement waste minimization measures as specified in RCRA for hazardous and radioactive mixed wastes." The order requires the heads of field organizations to "implement a waste minimization program for hazardous and radioactive mixed wastes."

DOE Order 5820.2A establishes policies, guidelines, and minimum requirements by which DOE manages its radioactive and mixed waste and contaminated facilities. It states that the "generation, treatment, storage, transportation, and/or disposal of radioactive wastes, and the other pollutants or hazardous substances they contain, shall be accomplished in a manner that minimizes the generation of such wastes across program office functions and complies with all applicable Federal, State, and Local environmental, safety, and health laws and regulations and DOE requirements." The order requires the preparation of a waste management plan for each site that generates, treats, and stores, or disposes of DOE wastes. The elements of the waste management plan are incorporated into the site-specific plan, which "will

indicate actions to minimize hazardous waste generation" as specified in the order.

DOE Order 5820.2A contains specific waste minimization requirements for management of high level, transuranic, and low-level waste. These requirements include process modification process optimization, and materials substitution.

DOE has instituted a "Waste Reduction Policy Statement." The policy consolidates the requirements of DOE Orders 5400.1, 5400.3 and 5820.2A for either a waste minimization or a waste reduction plan and attaches guidance for satisfying the reporting requirements of those orders. The statement adopts the hierarchical approach to waste reduction and applies the policy to all types of waste. The policy requires waste reduction to be a "prime consideration" in research activities, process design, and facility design and operations.

D. Mission and Site Description. Los Alamos National Laboratory (LANL) is owned by the U.S. Government, which co-operates the facility with the University of California, the prime contractor for those operations involving waste generation and management. The prime contract is administered by the DOE Albuquerque Operations Office, through the DOE Los Alamos Area Office. Johnson Controls Incorporated (JCI) provides the major support work for the Laboratory and generates waste from it's own operations.

The Laboratory comprises 43 square miles in north-central New Mexico (See Appendix A) and employs approximately 12,000 people. The principal mission of the Laboratory is the design and development of weapons for the nation's nuclear arsenal. In addition, considerable research and development is directed toward developing the peaceful uses of nuclear energy, including research on fission reactors, nuclear safeguards, laser fusion, and medium energy physics. Extensive basic research programs in physics, chemistry, metallurgy, mathematics and computers, earth sciences, and electronics support these efforts. Biomedical and environmental research programs include programs in molecular biology, radiobiology, radioecology, and industrial hygiene. Expansion into nonnuclear areas is represented by applied technology development of solar and geothermal energy and superconducting power transmission lines. The facilities that eventually became LANL were originally constructed in the middle 1940's.

LANL is committed to environmental protection, and responsible waste management. As a result, waste

minimization is given top priority while waste management and corresponding activities are carefully controlled.

II. RESOURCES

A. Program Budget. In Appendix B, the Los Alamos National Laboratory Annual Waste Reduction Report, the budget for the Waste Minimization and Pollution Prevention Awareness Program itemizes the funds allocated in the program.

B. Personnel. The number of full-time and part-time employees assigned is described in Appendix B.

III. POLICY

A. Statement of Management Support/Commitment. The Senior Laboratory Management and the Waste Minimization Program Office (WMPO) are totally committed to minimizing the generation of waste by giving preference to source reduction, material substitution, and environmentally sound recycling over treatment, control and disposal of such wastes. Senior management will take appropriate action to provide adequate personnel, budget, training, and material on a continuing basis to ensure that the objectives of the Waste Minimization and Pollution Prevention Awareness Program are met. Evidence of this commitment is a written Directors Policy (DP105) that establishes the Waste Minimization Program at LANL. DP105 as presently approved is shown in Appendix D. A draft of a revised Directors Policy, with increased emphasis on Waste Minimization is also shown in Appendix D. This revised Directors Policy is currently being reviewed.

B. Relevant Site Directives or Guidance. Waste Minimization techniques will be included in all relevant standard operating procedures for waste generating activities at LANL. The Administrative Requirements (as noted in the LANL Environment, Safety, and Health Manual) directing Waste Minimization and Waste Management are:

10-1 Radioactive Liquid Waste
10-2 Low-Level Radioactive Solid Waste
10-3 Nonradioactive Chemical Waste
10-4 Polychlorinated Biphenyls
10-5 Transuranic (TRU) Solid Waste
10-7 Excess Government Personal Property
10-8 Waste Minimization

IV. STRATEGY, OBJECTIVES, AND GOALS

A. Strategy. A waste minimization program has been developed to obtain accurate and current information on

waste stream generation and waste management cost which provide the basis for the implementation of specific waste minimization techniques and technologies. The program develops methods for collecting information, evaluating options, and identifying cost-effective waste minimization techniques. The essential elements of the strategy are to (1) maintain an organization that comprises line and staff representatives who develop and administer the waste minimization program, (2) define targets of waste to reduce, and (3) develop a method for tracking the performance and progress of the program.

B. Program Objectives. The objectives of the Waste Minimization and Pollution Prevention Awareness Program are the following:

1. Foster a philosophy to conserve resources and create a minimum of waste and pollution in achieving Laboratory strategic objectives. Promote the use of nonhazardous materials in plant operations to minimize the potential risks to human health and the environment. Reduce or eliminate the generation of waste materials through input substitution, product reformulation, process modification, improved housekeeping, and on-site closed-loop recycling to achieve minimal adverse effects on the air, water, and land.

2. Enhance communication of waste minimization objectives, goals, and ideas among site organizations. Promote integration and coordination of waste generators and waste managers on waste minimization matters. Characterize waste streams and develop a baseline of waste generation data.

3. Identify and implement methods and technologies for waste minimization. Target policies, procedures, or practices that may be barriers to waste minimization.

4. Create incentives for pollution prevention.

5. Develop and implement employee pollution prevention awareness and occupational training programs. Collect and exchange waste minimization information through technology transfer, outreach, and educational networks. Develop mechanisms for fully disseminating current technical information to Laboratory users.

6. Enhance employee awareness of pollution prevention goals.

7. Develop reasonable goals and schedules for waste minimization activities.

8. Comply with federal and state regulations and DOE requirements for waste minimization.

C. Goals. Appendix B includes those qualitative and quantitative milestones for the Waste Minimization and Pollution Prevention Awareness Program. These goals include numerical reduction and programmatic milestones for a comprehensive program. LANL has an overall waste reduction goal of 20% over three years. In addition, waste reduction goals for specific activities include: 20% through administrative controls and process modifications due to PWAs, 20% LLW through segregation, 40% through chemical recycle, 60% through solvent substitution and recycle, and 75% in electroplating wastes through process modification.

D. Schedule of Activities. A schedule of waste minimization activities and milestones is presented in Appendix B, and Appendix C, the Process Waste Assessment Plan.

V. ORGANIZATION AND STAFF RESPONSIBILITIES

The Environmental Management Division (EM-DO) has primary responsibility for the management of the Waste Minimization Program. The Director and the staff in support of the DOE field or Operations Office have general oversight and implementation responsibility of the program.

The waste minimization organization consists of the Waste Minimization Program Office (WMPO) of EM-DO and the Waste Management Coordinators that are assigned within each waste generating group. This core organization is supported by the Laboratory Training Office and personnel from other HS/EM groups (Figure 1).

The minimization goals of the WMPO are to provide every generating group with a base of technical knowledge in waste minimization, waste management, appropriate procedures, to identify applicable problems, and appropriate solutions in waste minimization and waste management.

The WMPO also interfaces with generators to anticipate changes that arise from program changes, emerging technologies, changing disposal requirements, and regulatory changes. From this proactive position, the WMPO will continue to identify waste minimization opportunities.

The program organizational structure is designed to maximize the dissemination and collection of waste minimization information and provide waste generating organizations with managerial responsibility for the development, design, construction, and implementation of waste minimization projects.

A. Waste Minimization Program Office. The WMPO charter includes oversight of administrative and technical methods for waste minimization, segregation, and education. Team members take the necessary steps to change procedure and policy, when required. They provide waste management overview and guidance for administrative efforts dealing with waste generation, disposal, and minimization.

The WMPO develops educational and training materials and teaches some of the waste management and minimization courses. This educational process includes formal classroom settings, informal briefings to generating groups and Waste Management Coordinators, and individual sessions for solving specific problems. Team members also develop and distribute technical bulletins on waste minimization and other pertinent information. The WMPO maintains the electronic data base required to supply the technical information needed for process changes and substitutions.

The responsibilities of the WMPO include:

- Serve as the Site Waste Management Coordinator
- Defining the objectives of the waste minimization program in accordance with this plan,
- Obtaining waste generator support and input for the program,
- Facilitating integration and coordinated interaction between waste generators and waste managers on waste minimization matters,
- Establishing waste minimization goals and objectives,
- Sponsoring ongoing employee awareness and training,
- Coordinating program participation by represented areas,
- Prioritizing waste streams or facility areas for assessment,
- Assisting teams to conduct process waste assessments,

LANL Waste Minimization Hierarchy

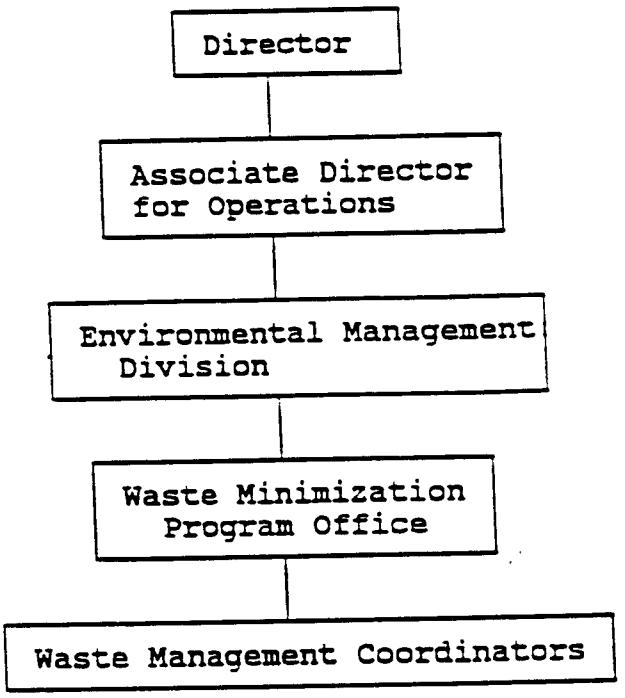

Figure 1

- Recommending and ranking options for management implementation,

- Monitoring performance of waste minimization options that have been implemented and evaluating performance accordance to success criteria,

- Monitoring and reporting progress of the waste minimization program, utilizing audits and monthly reviews,

- Recommending personnel for achievement and incentive awards, and

- Facilitating technology transfer and pollution prevention awareness.

B. Waste Minimization Steering Committee. A permanent committee will be established to define an effective waste minimization system and oversee the waste minimization program. The committee will be composed of senior representatives from line and staff organizations that have a significant interest in the results of the program. The members of the committee will be appointed by the Laboratory Associate Directors. The LANL Waste Minimization Coordinator (a member of the WMPO) will chair this Committee.

The primary functions of the Waste Minimization Committee will include: providing employee awareness of the Waste Minimization and Pollution Prevention Awareness Program, identifying tasks which help to implement the program, and providing a mechanism for inter- and extra-laboratory communication regarding waste minimization. This Committee will have oversight of the WMPO and work in conjunction with the WMPO.

C. Waste Management Coordinators. Each waste generating group must provide a coordinator who is the focal point of waste minimization and waste management within the group.

Waste management coordinators need to know the processes and systems that generate waste within their groups. HS provides coordinators with additional training to enhance their ability to minimize and manage waste. Coordinators are encouraged to review their operations in detail and find specific ways to reduce waste on an ongoing basis.

VI. COST ACCOUNTING

A cost accounting system will be devised that accounts for the "true cost" of waste that is generated at the Laboratory and permits meaningful reviews and audits to be conducted. The system will calculate the short- and long-term costs arising from (1) under utilization of raw materials found in the waste stream, (2) management of the wastes that are generated, (3) waste disposal, and (4) third-party liabilities if the waste is improperly disposed of. Associated costs will include personnel, recordkeeping, transportation (including on-site movement), pollution control equipment, treatment, storage, disposal, liability, compliance, and oversight costs. Currently, the WMPO provides informational bills to waste generating groups which includes comparative waste generation volume data. By September, 1992, the bills should also include waste disposal cost information. Appendix B, Figure 3, shows cost accounting milestones.

VII. PROCESS WASTE ASSESSMENTS

Process Waste Assessments (PWAs) will be conducted as part of an ongoing program to identify, screen, and analyze options to reduce the generation of waste. A process waste assessment determines the amount of material in a workplace that is disposed of as waste during work operations. It provides a summary of hazardous materials usage and waste production and identifies those processes and operations that need to be improved or replaced to promote waste minimization. The assessment provides a basis for prioritizing the specific modifications to site processes or other waste minimization options that are developed during the assessment.

Assessments of all waste-generating operations at the site will be performed by Process Waste Assessment Engineering Teams organized by the WMPO. The leader of each team will be an intermediate-level manager who has line responsibility, familiarity with the site's production and waste management operations, and proven technical and problem-solving abilities.

The remainder of each assessments team will be drawn from line, staff, or subcontractor organizations, who can furnish the types of specialized expertise that will be needed to conduct the assessment.

The WMPO will determine the priority of site operations to be assessed. Each Waste Assessment Team will develop process area flow diagrams, material balances, process descriptions, and waste stream characterizations for the assigned assessment area. Guidance found in the Waste Minimization

Guidance for Process Waste Assessments and EPA Manual for Waste Minimization Opportunity Assessments will be used in conducting the assessments. Completion of the flow diagrams, material balances, and related narratives will permit the identification process inefficiencies that may be modified or corrected to reduce waste generation. These waste minimization opportunities will be evaluated and identified with specific projects, which when implemented will reduce the volume and toxicity of the waste streams. Each team will report the data and findings from its assessment and recommend options for waste minimization. In identifying waste minimization options, the Waste Assessment Teams will concentrate first on source reduction options, followed by recycling technologies.

The WMPO has developed a methodology to provide generator ownership of Process Waste Assessments that meet the needs of a dynamic laboratory environment that exists at LANL. This methodology will allow the Process Waste Assessment Engineering Teams to train and work with the generator so that the PWAs can be done on an ongoing basis. In addition, the methodology includes a database with a graphical interface to provide the user with a process modeling tool. Appendix C, the Process Waste Assessment Plan includes milestones and goals for the initiation of PWAs at LANL. The initial database was developed in October, 1991.

VIII. WASTE MINIMIZATION TECHNIQUES

Waste minimization includes those activities that minimize or eliminate the generation of waste and recycling processes that use, reuse, or reclaim a material from a waste stream. Some activities commonly thought to be waste minimization are waste treatment. The following activities are not considered waste minimization:

1. Transfer of hazardous constituents from one environmental medium to another.

2. concentration conducted solely for reducing volume.

3. Dilution as a means of toxicity reduction, unless later recycling steps are involved.

If the activity is to make the material more amenable for disposal (e.g., reduce volume or toxicity before storage or disposal) then the waste is being treated, not minimized.

Techniques that are appropriate for particular types of waste are described in Appendix B. The following waste minimization techniques will be employed to minimize the generation of waste.

Inventory Management. Current methods to control the types and quantities of materials in the site inventory will be reviewed. Where necessary, inventory control techniques will be revised or expanded to reduce inventory size and hazardous chemical use while increasing inventory turnover. In particular, inventory control techniques will be used to reduce waste resulting from excess, out-of-date, and no-longer-used raw materials. Similarly, material controls will be revised or expanded to reduce raw material and finished product loss and damage during handling, production, and storage.

The inventory management techniques will be applied to waste material as well as to raw materials and finished products.

The review of inventory management techniques will include a study of how existing inventory management procedures can be applied more effectively, whether new techniques should be added to or substituted for current procedures, the need for review and evaluation approval procedures for the purchase of materials, and the need for additional employee training.

Operational Procedures. The generation processes within the site will be examined to determine whether significant reduction of waste at its source can be achieved by improvements in process efficiency. Operating procedures are be examined to determine whether the elimination or revision of SOPs can contribute to the reduction of waste. The revision and review of operating procedures will be fully documented and incorporated as part of the site's employee training program. In addition, the WMPO will participate in the LANL Environmental, Safety and Health Questionnaire Committee to review projects and plans prior to initiation. This will allow potential generators to include waste minimization in the conceptual design phase of a project.

Maintenance Program. The site equipment maintenance program will be reviewed to determine whether improvements in corrective and preventive maintenance can reduce waste generation caused by equipment failure. The methods for maintenance cost tracking and preventive maintenance scheduling and monitoring will be examined.

A determination will be made as to whether maintenance procedures are contributing to the production of waste in the form of process materials, scrap, and cleanup residue. The need for the revision of operational procedures, equipment modification, source segregation, and recovery as they apply to maintenance will be examined.

Material Change and Process Equipment Modification. The replacement, reformulation, reduction, or elimination or hazardous material sin production, maintenance, and cleaning

processes will be examined. The effect of waste reduction by the installation of new equipment or the modification of existing equipment will be considered. Techniques, such as segregation, to separate hazardous wastes and recoverable wastes from the total waste stream will be explored.

Recycling and Reuse. The recovery of wastes will be used as an option in the waste minimization program after first considering reducing the amount of waste generated at the source. Opportunities for reclamation and reuse of waste materials will be explored whenever feasible. Decontamination of tools, equipment, and materials for reuse or recycle will be used to the extent practicable to minimize the amount of waste for disposal.

IX. TRAINING, AWARENESS, AND INCENTIVES

A. Training Goals. One of the most important elements of the Waste Minimization and Pollution Prevention Awareness Program is training. The training program includes all levels of personnel within the site. The goal of the training program will be to make each employee aware of waste generation, its impact on the site and environment, and ways waste can be reduced and pollution prevented.

B. Employee Orientation Program. A waste minimization and pollution prevention awareness orientation program is established and is integrated into the General Employee Training (GET) orientation program for all employees. The orientation program will include the following elements:

- The need for, and benefits to be derived from, waste minimization and pollution prevention;
- The contribution each employee can make to an improved working and living environment;
- Management commitment to waste minimization and site waste minimization policy;
- Improved operation practices for reducing waste generation; and
- solicitation of waste minimization and pollution prevention ideas and the discussion of solution to identified problems.

C. Specialized Training Program. Specialized training sessions on pollution prevention policy and procedures and waste minimization techniques will be tailored for management, line, and staff position. These sessions will be incorporated into the regularly scheduled

training program. The adequacy of training procedures and of any special equipment needed to perform waste minimization functions will be evaluated annually by the WMPO.

D. Procedures Qualification. As part of quality assurance (QA), certain employees are required to be trained and examined on their knowledge of site SOPs prior to performing work. Waste minimization will be incorporated into operating, administrative, and waste procedures requiring documentation using data sheets or forms. Training on waste minimization, therefore, will also be conducted as part of the QA procedures qualification process.

E. Performance Evaluation. Waste minimization goals, objectives, and accomplishments will be incorporated into annual evaluations of job performance for those persons who have waste minimization responsibilities. These evaluations will be done annually, according to written procedures which include QA review.

F. Pollution Prevention Awareness. The Pollution Prevention Awareness Program required by DOE Order 5400.1 has been incorporated with the Waste Minimization Program. The purpose of the Pollution Prevention Awareness Program is to foster the philosophy that prevention is superior to repudiation. The goal of the program is to incorporate pollution prevention into the decision-making process at every level throughout the organization.

The Pollution Prevention Awareness Program has the following objectives:

- Make employees aware of general environmental activities and hazards at the site and waste minimization program requirements, goals, and accomplishments;
- Inform employees of specific environmental issues;
- Train employees on their responsibilities in pollution prevention;
- Recognize employees for efforts to improve environmental conditions through pollution prevention;
- Encourage employees to participate in pollution prevention;
- Publicize success stories.

The program consists of four elements: (1) Pollution Prevention awareness campaign, (2) Awards and recognition, (3) Information exchanges, and (4) Training.

The Pollution Prevention Awareness Campaign will be conducted at least once each year. It will be developed by the Waste Minimization Committee.

The Campaign will make extensive use of site newsletters, seminars, bulletin boards, signs, and slogans to enhance employee awareness of and participation in pollution prevention at the site.

The remaining elements of the Pollution Prevention Awareness Program are described in other sections of this plan. Incentive Awards and Recognition are discussed in Paragraph G. Information exchange is discussed in Section XII. Training has been discussed in Section IX, Paragraphs A through D.

G. Incentive Awards and Recognition. There is a Waste Minimization Employee Award Program at LANL. This program was initiated in October, 1991 and first awards will be given by the end of Fiscal Year 1992. Details on training and awareness milestones are shown in Figure 3, Appendix B.

X. TRACKING AND REPORTING SYSTEMS

A. Tracking From Point of Generation to Point of Disposition. A computerized tracking system will be developed to identify waste reduction opportunities and provide essential feedback to successfully guide future efforts. The system will identify program resource requirements and report cost benefits realized from implementation of waste reduction projects. The data collected by the system will be used for internal reporting and to meet external reporting requirements discussed in Paragraph D.

The system will track waste from point of generation to point of final disposition. The system will also permit the tracking of hazardous materials from point-of-site entry to final disposition ("cradle to grave") to comply with environmental regulations and reporting requirements. The system will collect data on input material, material usage, type of waste, volume, hazardous constituents, generating system, generation date, waste management costs, and other relevant information. A method will also be developed to track materials that are being recycled or reclaimed and volumes of wastes eliminated due to waste minimization efforts.

B. Procurement Control Systems. Procedures for control and purchase of hazardous chemicals or other material will be reviewed to determine whether improvements in those procedures will aid in the achievement of waste minimization goals. The tracking system described in Paragraph A will be used to track the purchase and usage of hazardous materials.

C. Program Activity Tracking. A computerized system will be developed to provide feedback on the progress of the Waste Minimization and Pollution Prevention Awareness Program, including the results of waste minimization technologies and other implemented waste minimization options.

D. Federal and State Reporting Requirements. Tracking systems developed under this program will be designed to facilitate reporting waste minimization data and accomplishments to the Department of Energy, Environmental Protection Agency, and New Mexico Environmental Department.

XI QUALITY ASSURANCE

Guidance implementing DOE Order 5820.2A stresses the requirement and need for quality assurance in conducting waste reduction activities. It indicates that waste reduction programs are required to "retain an appropriate level of documentation and accountability. The documentation of these programs should be designed to satisfy all requirements of the Waste Operations Quality Assurance Program at each field office."

A. Quality Assurance Program Plan. The proper documentation of waste minimization activities is critical to attaining an adequate level of confidence that the requirements of the DOE orders requiring minimization of waste are being met. A QA program plan will be developed for the Waste Minimization and Pollution Prevention Awareness Program as required for all programs by DOE Order 5700.6B and WMP 2.3.1. "Development of Quality Programs/Project Plans." The plan will be consistent with the Waste Operations Quality Assurance Program of Albuquerque Operations Office. The plan will specify documentation that will enable verification of data reported in manifests and biennial reports, and ensure that the character of all wastes can be verified and traced to their source. QA personnel will have yearly input to the program evaluation process. This process will be in place by September, 1992.

B. Quality Assurance Training. Site QA training will be revised to include waste minimization procedures and documentation. As discussed in Section IX, Paragraph D,

the QA procedures qualification process will include training and qualification on waste minimization procedures.

XII TECHNOLOGY TRANSFER AND INFORMATION EXCHANGE

All program staff are encouraged to make regular use of the EPA database (PIES) and the WIN system. The Waste Minimization Committee will foster participation in business, education, and government forums that are designed to provide technical assistance and exchange waste minimization information. Involved individuals will attend the semiannual DOE Workshop on Waste Minimization and to regularly participate in the New Mexico Hazardous Waste Management Society conferences.

The transfer of federally developed technology between laboratories and potential users is a contractual responsibility of DOE facilities and laboratories. Activities involving technology transfer should be coordinated through the office or committee within the facility that has been designated to represent the facility on the Federal Laboratory Consortium (FLC) for Technology Transfer. The consortium promotes technology transfer through links to the public and private sectors and through support services such as training and assistance in implementing partnership opportunities (e.g., cooperative agreements and patent licensing). Opportunities for transfer of technologies specific to waste minimization programs may develop from information exchange systems, workshops, or topical conferences. Direct exchanges of process technology between facilities are encouraged, but the support services of FLC should be used where appropriate. Technology projects that are identified and implemented should be coordinated with the Headquarters' Office of Technology Development. The WMPO team personnel regularly attend and present papers at off-site technical conferences. In addition, the research atmosphere of LANL promotes development of new technologies. The WMPO team acts as a liaison between those in fields with practical problems and those who develop solutions.

Information exchange at seminars, conferences are enhanced with monthly articles in the employee Newsbulletin.

XIII RESEARCH AND DEVELOPMENT

Proposals for research and development (R&D) would be expected to arise from the WMPO evaluation and ranking of waste minimization options. Some options may require development work before being implemented. The assessment may also identify process inefficiencies that offer the

potential for significant waste reduction, but specific process modifications may require R&D work before implementation can be scheduled. Budget requests should include support for appropriate R&D. Specific proposals for R&D work would be coordinated through Operations Office and the Office of Technology Development at Headquarters to ensure effective allocation of resources. Activities involving technology transfer are reviewed and approved within LANL to maintain coordination through the Federal Laboratory Consortium.

XIV PROGRAM EVALUATION

The Waste Minimization and Pollution Prevention Awareness Program will be evaluated annually. All major activities will be reviewed. The evaluation will document program achievements and identify potential areas for improvement. QA personnel will have performed the final quarter of the fiscal year.

Generally, the evaluation of potential waste reduction techniques is performed by those who eventually apply the techniques. The WMPO team will do some preliminary testing to eliminate particular technologies if it is determined that those technologies are not applicable to LANL waste problems. However, most waste reduction techniques are application-specific and evaluation by the user is much more reliable than evaluation solely by the WMPO team. The techniques and their application. An audit of the 1990 Waste Minimization Program was done by a private contractor. Those issues raised have been addressed in the 1991 plan.

The following success criteria will be used to demonstrate the effectiveness of waste minimization efforts:

1. Reduced amount of hazardous waste,
2. Reduced amount of all waste,
3. Reduced waste management costs,
4. Improved regulatory compliance,
5. Reduced health risks,
6. Improved public relations, and,
7. Increased production efficiency.

The WMPO team will address these criteria when evaluating the success of process or their changes to achieve waste volume or toxicity reductions. An accurate assessment for each of the appropriate criterion will be provided in evaluating the

success of each waste minimization option that has been implemented.

The report will be made to the Laboratory ES&H Council and Director and will contain current-year data, performance trends, forecasts, and measures used to gauge the performance of waste minimization activities. The evaluation report will be used to establish future waste minimization goals and program objectives. The report will also be used to determine changes to this plan.

Procedures for a Waste Minimization program evaluation was drafted by 9/30/91 in conjunction with the Quality Assurance Program and will be used for the Calendar Year 1991 program evaluation by the end of Fiscal Year 1992. The milestones for program performance evaluation are shown in Appendix B.

XV. WASTE GENERATION

Available waste generation data, baseline data, and priority waste generators is shown in Appendix B.

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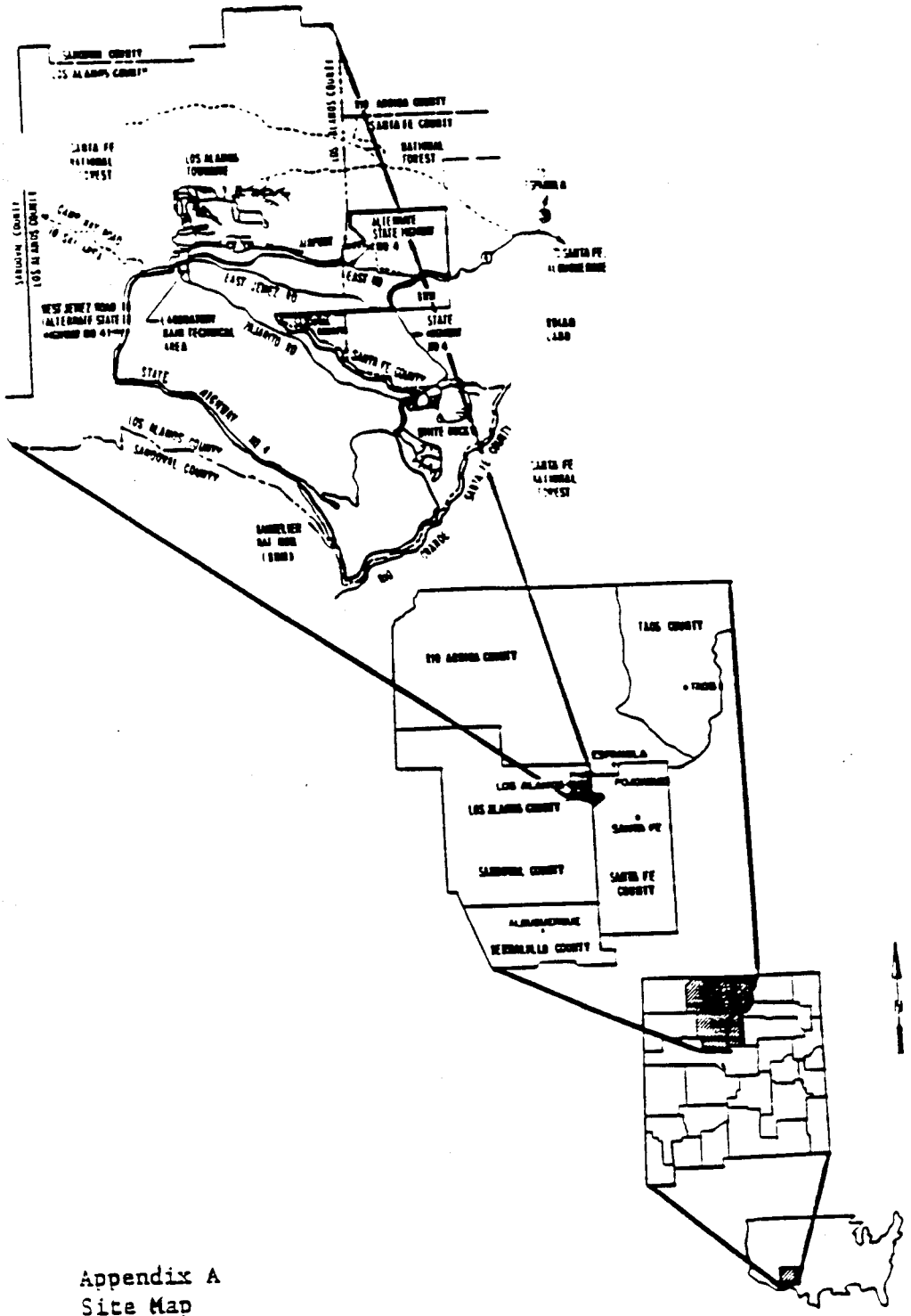
APPENDIX A

SITE MAP



Appendix A
Site Map
Los Alamos National Laboratory

APPENDIX B

LANL ANNUAL WASTE REDUCTION REPORT FOR 1991

LOS ALAMOS NATIONAL LABORATORY
1991 WASTE REDUCTION REPORT

MARCH, 1992

WASTE MINIMIZATION PROGRAM OFFICE

EXECUTIVE SUMMARY

The Waste Minimization Program Office (WMPO) at Los Alamos National Laboratory (LANL) is committed to a proactive and innovative program at LANL. The information in the Annual Waste Reduction Report tracks, for calendar year (CY) 1991, waste minimization activities at LANL as adminimistered through the WMPO. In addition, this report describes how waste minimization activities have been managed by the WMPO. Specific information described includes: program administration, budget, waste generation data, programmatic and numerical milestones, and pollution prevention awareness.

The Annual Waste Reduction Report is required by DOE Orders 5400.1 and 5820.2A.

1. INTRODUCTION

The Waste Minimization Program at Los Alamos National Laboratory (LANL) is administered through the Waste Minimization Program Office (WMPO) in the Environmental Management Division Office (EM-DO). The WMPO provides oversight to the Waste Minimization Program and technical assistance to generators at LANL.

2. PROGRAM ADMINISTRATION

This section outlines the organizational structure of the Waste Minimization Program at LANL, waste generation data, baselines, and those administrative milestones designed to ensure a quantifiable and effective Waste Minimization Program.

A. Structure of Waste Reduction Program

The Waste Minimization Program at LANL is made of four hierarchical tiers. The Directors Office is the top of the organizational structure, followed by the Associate Director for Operations, the Environmental Management Division Office, the WMPO, and, finally, by the Waste Management Coordinators (WMC) who are personnel from each waste generating organization trained to disseminate information regarding waste reduction efforts and methods to the waste generators. The WMPO currently has a program manager and four technical members in addition to vacancies for two process waste engineers. Additional support is provided by off-site contractors. These organizational structures are depicted in the organizational charts, Figures 1 and 2.

B. Waste generation data, baselines, and stream prioritization

Appendix A shows waste generation by Group and Division at LANL for hazardous, low-level waste (LLW), transuranic (TRU), and mixed waste. Appendix B includes baseline generation data from Fiscal Year (FY) 1986 through FY1990 versus FY1991, trends in waste generated from FY1986 through FY1991, types of waste managed during FY1991, and major generating groups for each waste category described above. The tables list every waste generating organization at LANL; blanks in the data for a given waste category indicate that the organization did not generate that type of waste.

The baseline is an average of solid waste generated from FY1986 through FY1990. A comparison is made with waste generated in FY1991 (Figures 6 and 7). This data is for a dynamic

laboratory environment, so there are limitations inherent in attempting to provide baseline data. These limitations will be improved with the initiation of the Process Waste Assessments (PWAs).

The types of waste managed show that hazardous and LLW are the major categories of waste generated (Figures 8 and 9). Major generators shown in Figures 10-13 of Appendix B are the priority generators. PWAs and walkthroughs with these groups should reduce these significant waste generation figures. Prioritization is done with regard to a number of criteria, however, the major considerations are: identifying the largest waste generators, and the largest types of wastes generated. When the priority generators and wastes are defined (Figures 6-13 in Appendix B), walkthroughs, site-specific plans, and application of the PWA system for those waste streams which are the most feasible for reduction can be targeted as a high priority activity. Increases in the volume of waste generated in FY1991 (compared to past years) are assumed to be the direct result of preparation for the Tiger Team visit in late 1991.

C. Administrative activities and milestones

This section describes those programmatic and regulatory milestones established to increase the effectiveness of the Waste Minimization Program. Most of these goals/milestones are qualitative, and the milestone chart is shown in Figure 3.

SENIOR MANAGEMENT POLICY STATEMENT: LANL has a draft Waste Management and Minimization Policy Statement to be issued by the Senior Management Group. This is a revision of a previous policy statement which will have greater Waste Minimization emphasis. The milestone for issuance is July, 1992.

EM/DP WASTE MINIMIZATION COORDINATION: Funding for waste minimization restricts Environmental Management (EM) to fund planning and oversight activities while Defense Programs (DP) and other generators fund implementation. To coordinate these funding restrictions, a LANL coordinator has been designated as a liaison between the funding responsibilities of EM and DP, allowing future waste minimization activities to proceed more efficiently.

WASTE MINIMIZATION STEERING COMMITTEE: The WMPO and LANL senior management are organizing a Waste Minimization Steering Committee to facilitate inter-laboratory communication and the identification, research, development, implementation, and funding of waste minimization techniques. The draft charter has been prepared and committee members should be identified in Spring 1992. The Committee Chair will be the LANL EM/DP funding coordinator discussed in the previous paragraph.

LANL Waste Minimization Hierarchy

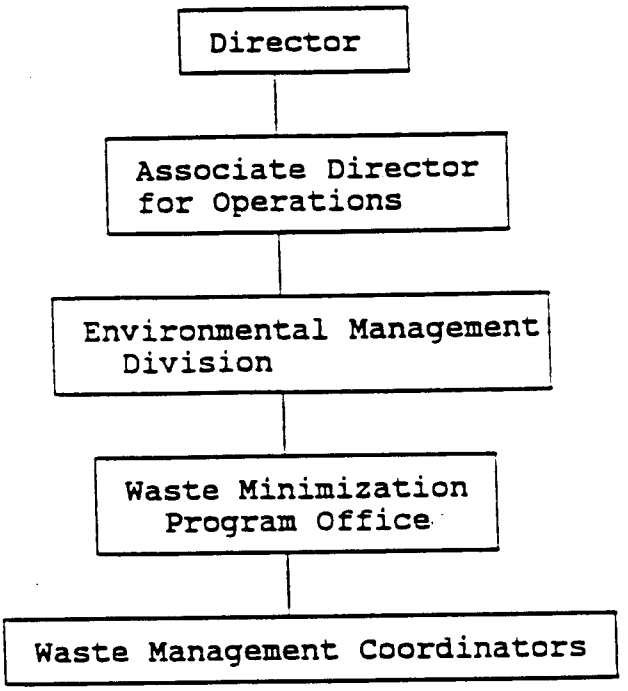
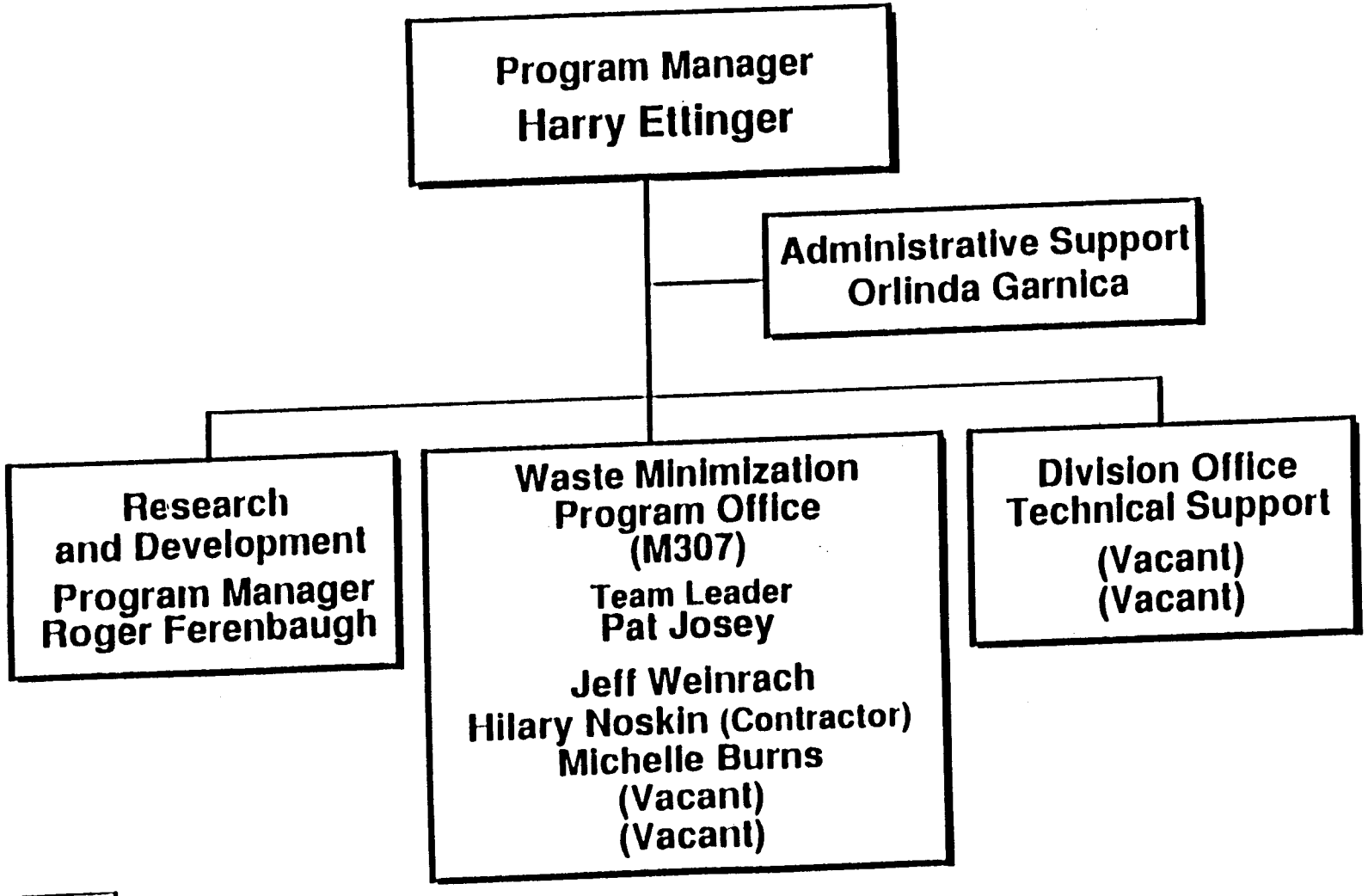


Figure 1

Waste Minimization/Technical Support

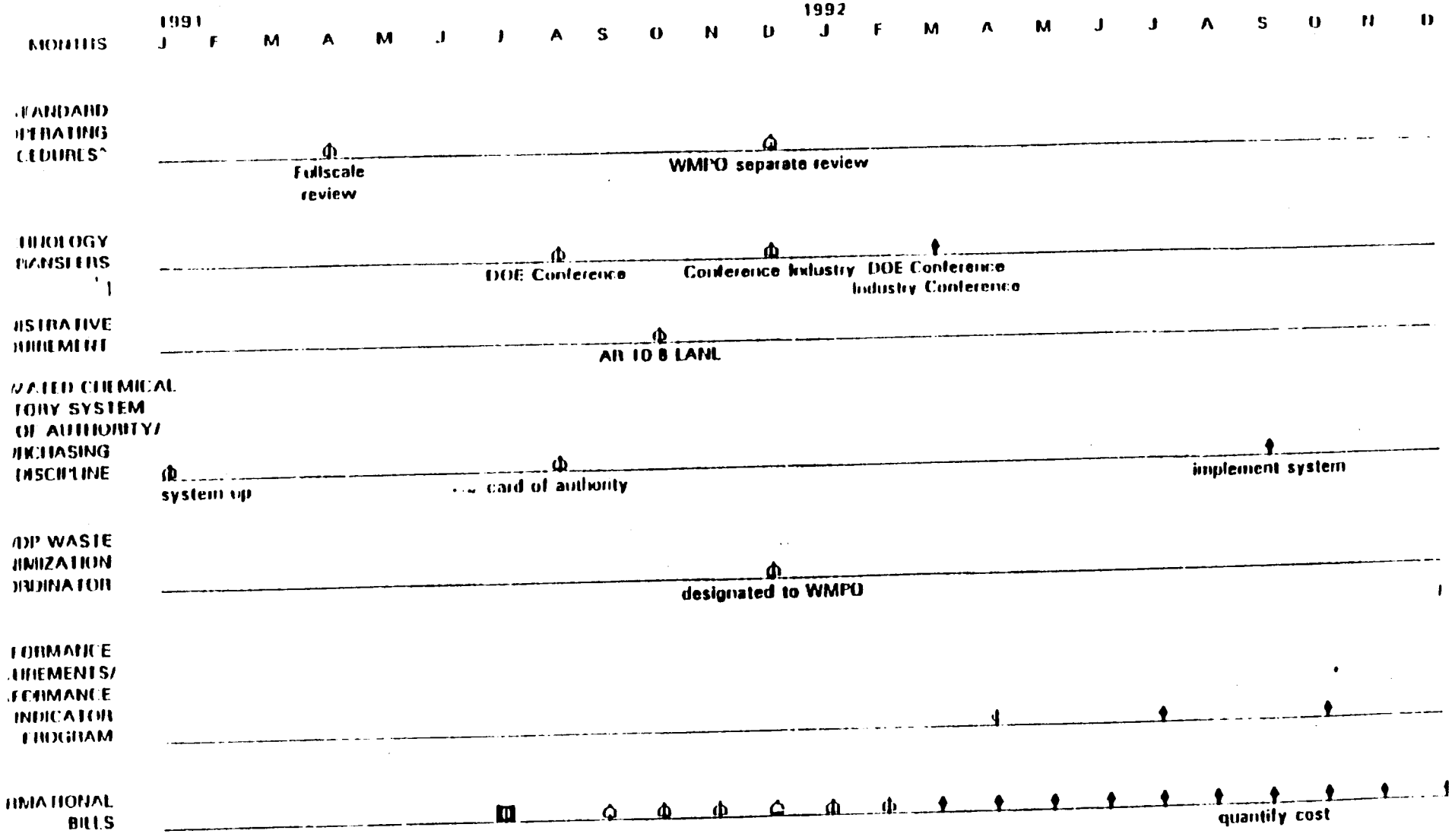


Environmental Management Division

Los Alamos

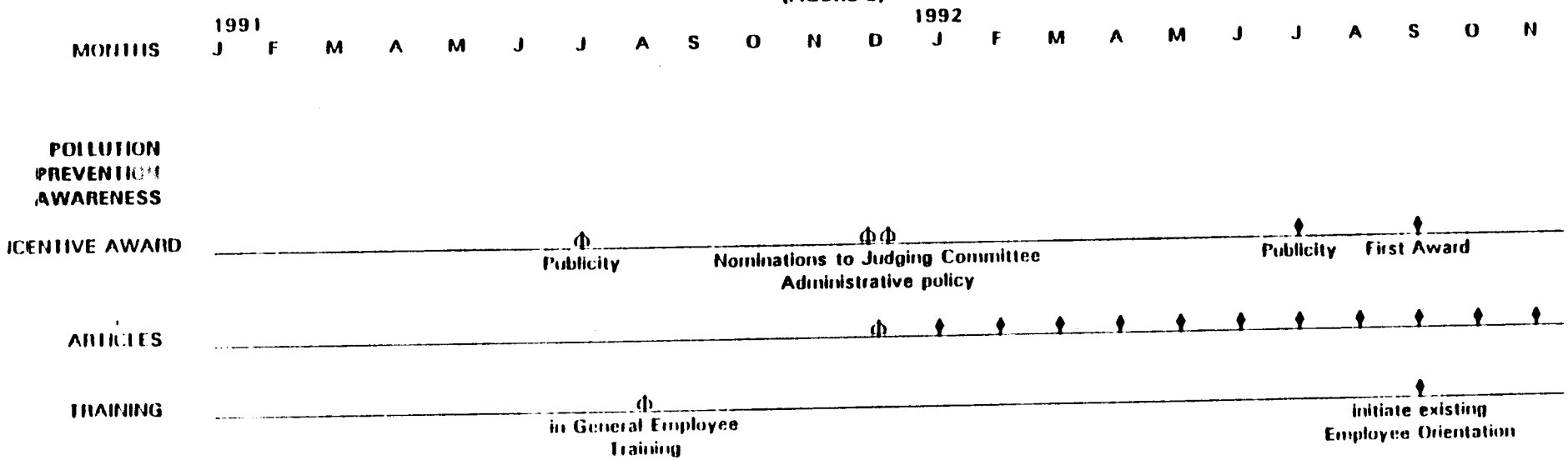
Figure 2

ADMINISTRATIVE MILESTONES
1991 - 1992
(FIGURE 3)



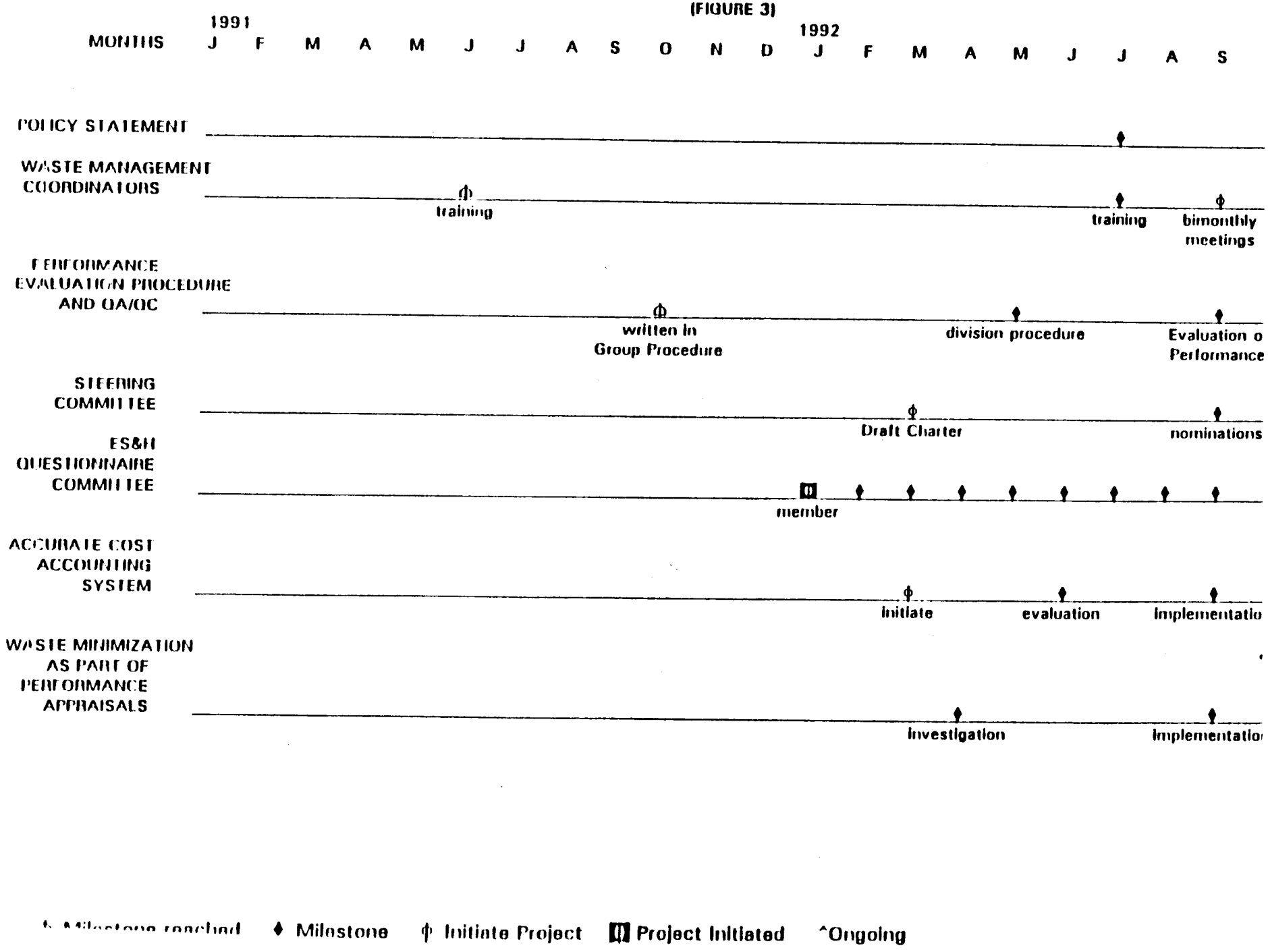
Initiate Project Project Initiated ^Ongoing

ADMINISTRATIVE MILESTONES
1991 - 1992
(FIGURE 3)



Initiate Project Project Initiated ^Ongoing

ADMINISTRATIVE MILESTONES
1991 - 1992
(FIGURE 3)



WASTE MANAGEMENT COORDINATORS: To ensure that LANL generators are in contact with the WMPO, Waste Management Coordinators (WMCs) have been assigned in every division for information dissemination. WMCs are part of the LANL Waste Minimization organizational structure, as described in Section 2-A.

ADMINISTRATIVE REQUIREMENT: The LANL Environment, Safety, and Health manual includes an Administrative Requirement (AR 10-8) concerning waste minimization. This document identifies the management and employee responsibilities to minimize waste to the maximum extent feasible.

ES&H QUESTIONNAIRE COMMITTEE: The WMPO currently has a member on the LANL Environment, Safety, and Health Questionnaire Committee which is a mechanism for LANL to address ES&H issues prior to project initiation. WMPO membership on this committe was established in January, 1992; this involvement is a valuable tool for identifying waste minimization opportunities in the conceptual design stage.

STANDARD OPERATING PROCEDURES: The WMPO reviews Laboratory Standard Operating Procedures for those processes that do or have a potential for generating waste. This review ensures that waste minimization techniques are employed throughout the operating process. This is a continuing activity.

PERFORMANCE MEASUREMENTS/PERFORMANCE INDICATOR PROGRAM: The WMPO is working with Laboratory generators to measure waste minimization successes, and waste reduction efforts. Generators complete periodic reports and send them to the WMPO; the reports are compiled and folded into the LANL Performance Indicator Program (PIP). The PIP is sent to DOE Headquarters. The generator reports were initiated January, 1992, and will be included in the April, 1992 PIP report.

PERFORMANCE EVALUATION PROCEDURE/QA/QC: The WMPO has procedures for a program performance evaluation/self-assessment to be conducted annually. The performance evaluation will be conducted annually and will be independently reviewed by LANL QA/QC personnel. This evaluation will allow WMPO to identify qualitative and quantitative strengths and weaknesses, and a method of action to improve on both.

INFORMATIONAL BILLS: The WMPO generates monthly informational bills to waste generatoring divisions. These bills allow the divisions to track their waste generation, as compared to the volumes produced during a similar portion previous FY. In the future, the WMPO anticipates modifying the format of these bills to inform generators of the costs to the Laboratory for managing the wastes they generate. This effort will assist the WMPO in developing a method to accurately account for the costs of waste generation and reduction.

TECHNOLOGY TRANSFER: The members of WMPO are active in many different technology transfer activities. Technology transfer mechanisms include: DOE and industry conferences, Pollution Information Exchange System (PIES) through the Environmental Protection Agency, Waste Information Network (WIN) through DOE, the Alternative Treatment Technology Information Center (ATTIC), papers in DOE and Industry publications, and DOE/LANL/industry collaborations.

CARD OF AUTHORITY/PURCHASING DISCIPLINE: Through the Automated Chemical Inventory System (ACIS), the WMPO and Administrative Data Processing Division at LANL are designing a "Card of Authority" system for purchase of chemicals. This system will allow only those people holding the card to purchase chemicals. To receive the cards, the employees must obtain training that is updated annually. This training includes waste minimization, environmental compliance and waste management procedures. This effort will reduce the purchase of excessive quantities of materials which will result in the production of wastes.

WASTE MINIMIZATION AS PART OF PERFORMANCE APPRAISALS: The WMPO is also working to have an item included on employee performance appraisals that identifies waste minimization as a part of their employment responsibilities.

3. PROGRAM DESCRIPTION

This section describes the budget for oversight of waste minimization, the milestones and activities for PWAs, and information about the LANL Pollution Prevention Awareness Program.

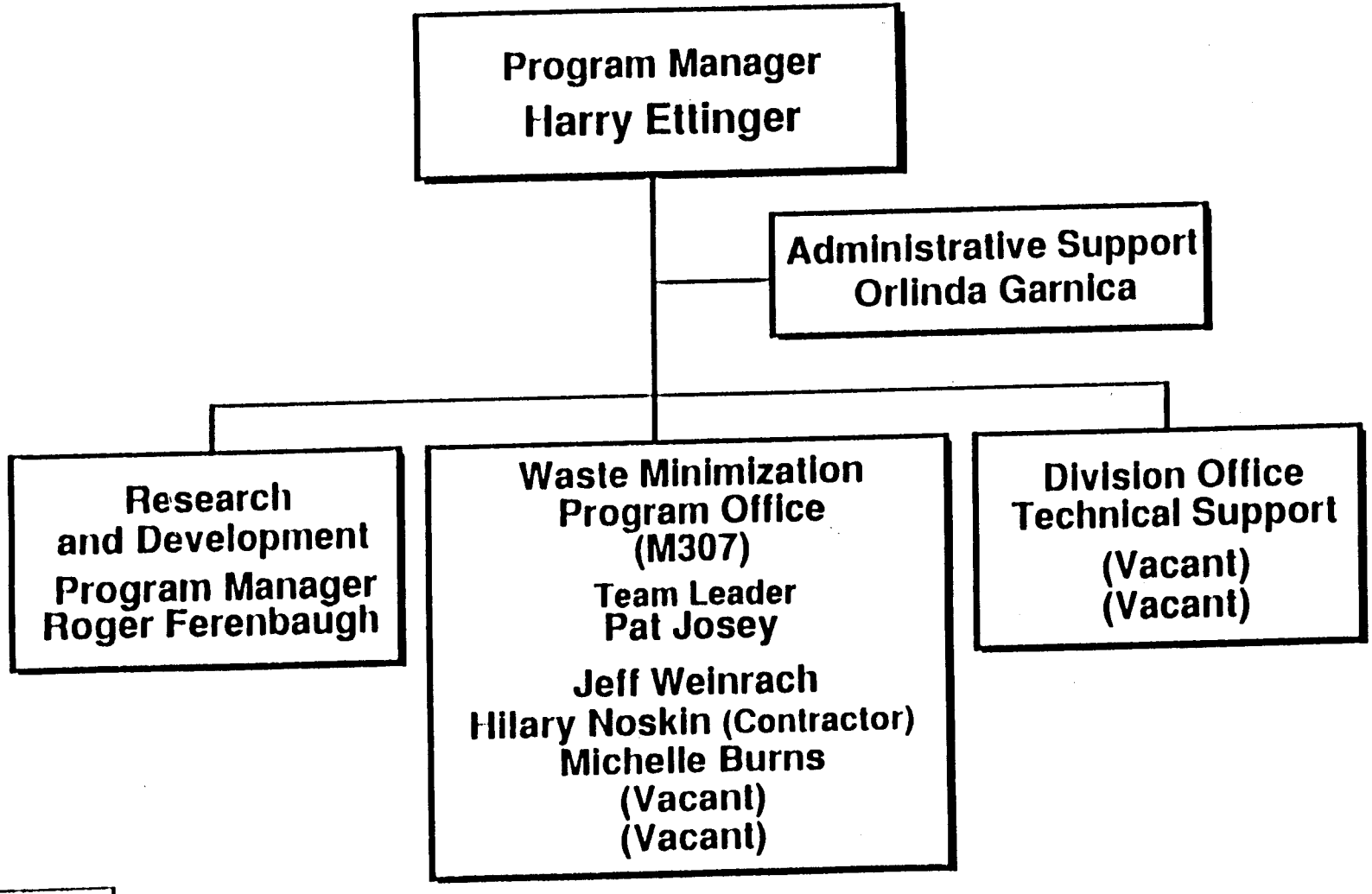
A. Budget

WMPO expenditures for FY1992 to date (through the end of December, 1991) include:

$202.9K for full-time employees, materials and travel,
$ 30.5K for Card of Authority,
$ 62.7K for LANL Management Taxes, and
(Annual tax for FY1992, not due in last 3 quarters)
$ 92.2K for Waste Management Tracking Database

Funding for the Waste Minimization Program support, guidance, and oversight for FY1992 is $1.9 million and supports 7 full time employees. Funding for implementation by programmatic sources has not been identified or requested. An additional allocation of $80K funds has been targeted for PWAs.

Waste Minimization/Technical Support



Environmental Management Division

Los Alamos

Figure 2

B. Administrative Radiation Limits

The administrative "background" radiation limits already applied during operations by the LANL Health Physics services groups has been determined to be 0.03-0.07 mr/hr.

C. Process Waste Assessments

PWA methodology has been designed for the dynamic laboratory environment at LANL. The PWAs are the backbone of the Waste Minimization Program and will serve not only as a tool to measure process efficiency, but will allow the generator to model processes for identification of waste minimization opportunities and their feasibility. After identifying waste reduction opportunities through modeling with the PWA software, technologies available for modifying the modeled process are researched. The PWA software also enables evaluation of identified technical solutions on a cost/benefit/risk basis. Milestones reached as of January, 1992 include database development, modeling, data justification/validation, and testing initiation. Five PWAs are due to be done by September, 1992. The milestone chart for PWAs is shown in Figure 4.

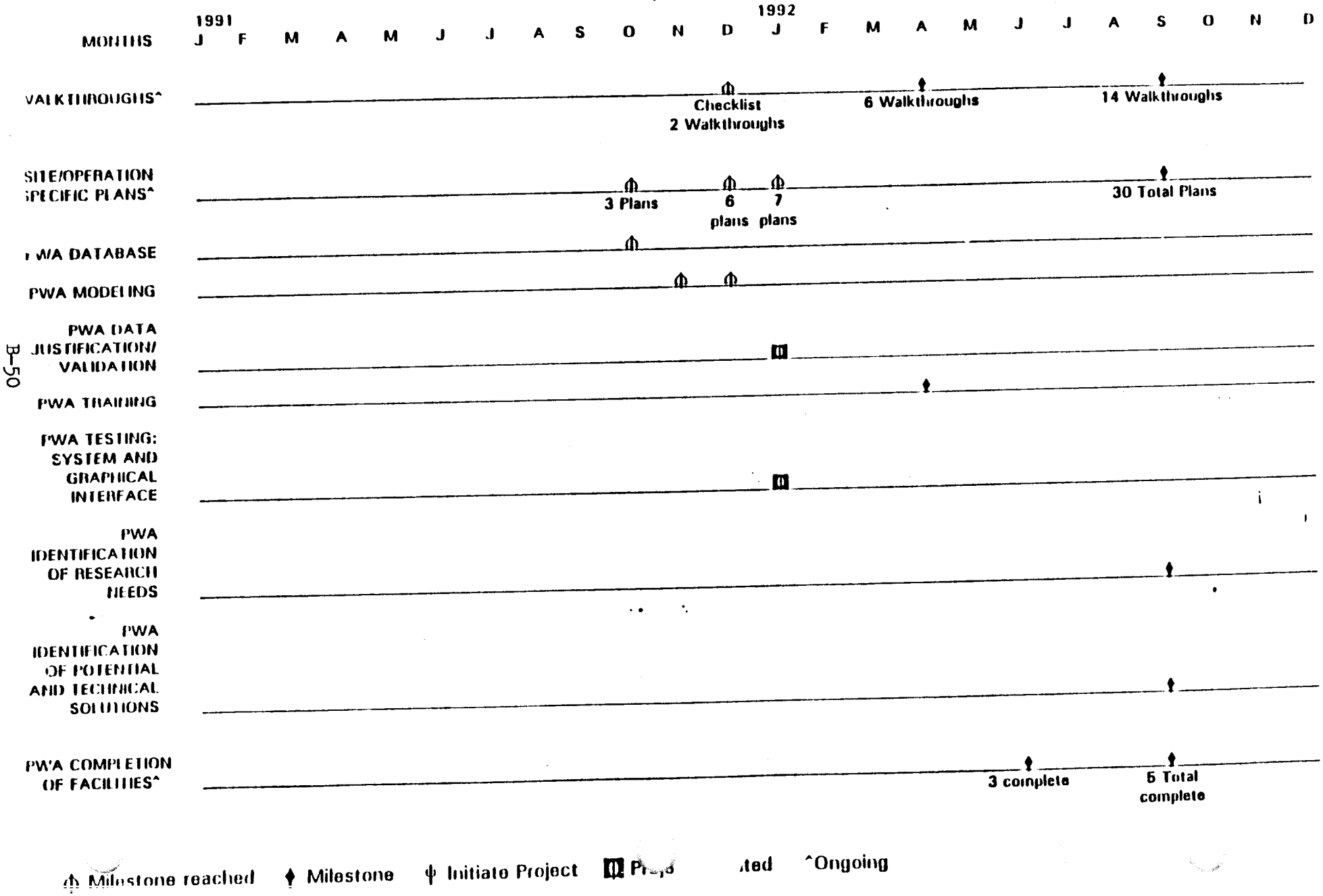
WALKTHROUGHS: The WMPO provides technical assistance to generators to assess their operations/processes on a site specific basis. The WMPO member and the generator "walk through" the operation/process and identify waste minimization opportunities for the generator to prioritize and implement. The walkthrough checklist and 2 walkthroughs have already been completed; 14 total walkthroughs are to be completed by the end of FY1992.

SITE SPECIFIC PLANS (SSP): SSP are written by the generator about their specific process/operation, and provide descriptive information about the process/operation to aid identification of waste minimization opportunities and implementation activities. Thirty of these plans are scheduled to be completed by September, 1992.

D. Pollution Prevention Awareness

TRAINING: New employee orientation and existing employee training for waste minimization has been developed. As of August, 1991, all new employees receive the Waste Minimization Orientation Video and training within the General Employee Training (GET). GET is required prior to receiving a badge as an employee of LANL. Waste Minimization Orientation Training for existing employees will begin by the end of FY1992 (Figure 3).

PROCESS WASTE ASSESSMENT MILESTONES
1991 - 1992
(FIGURE 4)



INCENTIVE AWARD PROGRAM: LANL has established a Waste Minimization Awards Program. This program is designed to award Laboratory employees for new or recently-implemented waste minimization ideas. The awards are cash, and can be up to $2,000 per person. The policy has been in effect since December, 1991, and the initial prizes will be awarded by September, 1992 (Figure 3).

ARTICLES IN EMPLOYEE NEWSBULLETIN: The LANL employee Newsbulletin has a monthly waste minimization article. This space is provided by the Newsbulletin and the article is prepared by the WMPO and a journalism professional from the Newsbulletin. The articles provide information designed to heighten employee awareness of waste minimization techniques and opportunities (Figure 3).

4. PROGRAM PERFORMANCE

This section describes performance successes and milestones for actual process changes to reduce waste. Table 1 lists those specific successes documented in CY1991.

A. Technical Activities and Milestones

This section outlines some technical activities on which the WMPO is providing assistance, or gathering information. Technical activities are performed by various LANL line organizations and indicate the breadth of interest/support for waste minimization at LANL. The milestone chart is shown in Figure 5.

ATLAS: ATLAS is a steam evaporator for nitric acid recovery from a plutonium/nitric acid effluent. Operators hope to recover 99% of the nitric acid for recycle and reuse in plutonium processing. The system also provides data for future scale-up engineering. The pilot scale project has been completed, and "hot" testing is underway. System hook up will begin in September 1992, with complete implementation in 12 months.

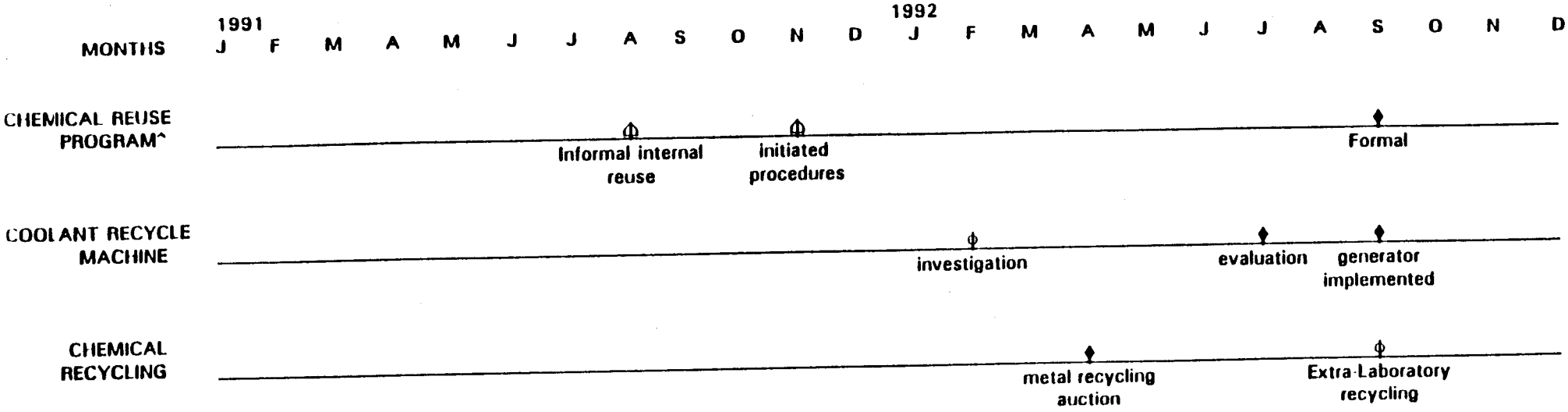
RADIOACTIVE MATERIALS MANAGEMENT AREA: The WMPO, in conjunction with the Waste Management Group, has been addressing the issue of adequate delineation of radiation areas for proper segregation of materials, employee awareness, and reduction of LLW. A new project directive and problem identification is being developed. An Administrative Requirement outlining the details of a Radioactive Materials Management Area (RMMA) should be developed by September, 1992, if operational problems can be overcome.

TABLE 1

LOS ALAMOS NATIONAL LABORATORY WASTE REDUCTION SUCCESSES

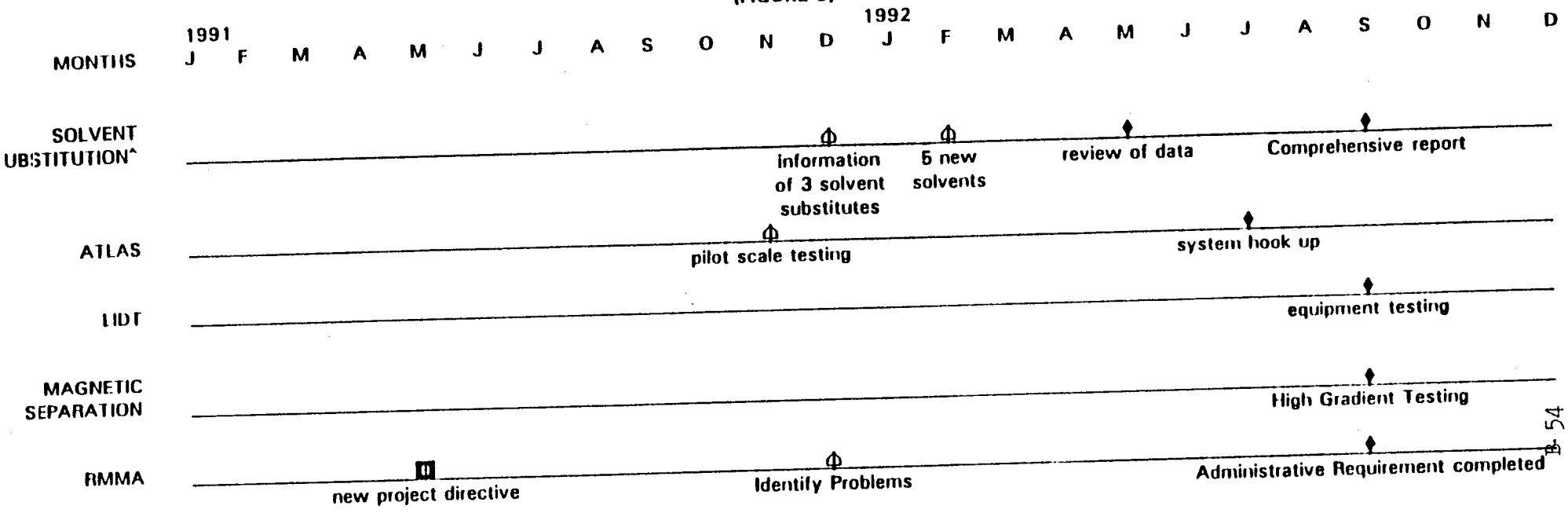
Waste Category	*Process/ Operation*	*Amount Reduced*	*Reduction Method*	*Dollar Savings*
Hazardous	Maintenance	1320 gal.	Solvent Recycle	$ 27,324
Liquid (Haz, Rad, Mixed)	Electroplating	208,000 gal.	Process Modification	686,400
Hazardous	Throughout LANL	1000 lb.	Reuse/Exchange Program	20,700
Sanitary	Throughout LANL	75% by volume	Recycling	no information
Sanitary	Throughout LANL	50% by volume	Salvage/Reuse	no information
Hazardous	MEC-Div Machine Shops	28,290 gal.	Materials/Solvent Substitution	311,514
Industrial-Fuel Oil	Throughout LANL	140.5 m3	Recycle through Fuel Blending	23,270

RECYCLING MILESTONES
1991 - 1992
(FIGURE 5)



Φ Milestone reached ♦ Milestone ϕ Initiate Project ◘ Project Initiated ^Ongoing

TECHNICAL MILESTONES
1991 - 1992
(FIGURE 5)



ELECTROPLATING: The WMPO has been providing technical guidance to the LANL electroplating shop to modify processes, for waste reduction. In 1991, spray guns were added above rinsewater tanks to reduce dragout. The subsequent reductions were 90% ion concentration reduction in rinsewater, allowing for 75% increase in use. The projected waste reduction from this modification for 1991-1992 is 208,000 gallons.

SOLVENT SUBSTITUTION: The WMPO is advising LANL machinists and scientists during their efforts to gather information on solvent substitution. As of December, 1991, information on three solvents had been acquired. The milestone is to test five more solvents by September, 1992, and compile a report from information available throughout the DOE complex and industry. In addition, the machine shop has put a limitation on general use of Methylene Chloride, Acetone, 1,1,1-Trichloroethane, Toluene, Xylene, Benzene, Kerosene, Trichloroethylene, Methyl Ethyl Ketone, Carbon Disulfide, Carbon Tetrachloride, and Tetrachloroethylene that has resulted in a waste reduction of 28,290 gallons of hazardous waste.

LiD-T RECOVERY: This unit is a water process unit which converts unusable Tritium to usable Tritium. Equipment testing will begin by September, 1992, and implementation by the generator will be by September, 1993.

MAGNETIC SEPARATION OF PLUTONIUM: This process recovers Plutonium from material mixtures including sludges and aqueous solutions. The process is projected to recover 100% of the Plutonium from the mixture. High-gradient testing will begin by September, 1992. Implementation is targeted for March, 1994.

B. Recycling Activities and Milestones

This section describes recycling activities at LANL, and is separated from the Technical section to provide a clear deliniation between source reduction and recycling. The milestone chart for these activities is shown in Figure 5.

CHEMICAL REUSE PROGRAM: LANL has two phases of a chemical reuse/reclamation program. The first is an informal, internal network where generators distribute information within the laboratory and users may claim these materials, thereby avoiding disposal. The second phase is a formal network with a centralized chemical repository, electronic database, and integrated into the ACIS. Procedures for the central facility have been written, and the system should be initiated by September, 1992. In addition, a fuel oil recovery system

exists at LANL and through fuel blending there was a resultant waste reduction of 140.52 m3.

EXTERNAL CHEMICAL RECYCLING: LANL is in the process of defining the contractual and regulatory mechanisms for recycling chemicals outside of the Laboratory. Initial estimates indicate that as much as 65% of used chemicals are readily recyclable. This program includes, but is not limited to fuel oil and metals. It is anticipated that this program will be operational by October 1992.

PAPER RECYCLING: LANL has as active paper recycling effort including white and colored paper. This project is ongoing and has been in effect since 1989. Approximately 75% of the Laboratory's paper waste has been recovered due to the recycle program.

SALVAGE: LANL has an active salvage program. This program is a method for reuse and sale of industrial and office materials that would otherwise go to the landfill. The items that are salvaged include: scrap metal, office furniture, lubricating oil, automotive batteries, and machine equipment.

SOLVENT RECYCLING: The WMPO and the Hot Dry Rock Project have been working together to reduce wastes generated at the Fenton Hill Site. The result has been a solvent recycling contract with Safety-Kleen, started in January, 1992, that will result in a 110 gallon/month reduction in hazardous wastes. LANL also has a mechanism for solvent recovery, of certain solvents, within the Laboratory. This program will be used more aggressively in 1992.

COOLANT RECYCLING MACHINE: The machine shop is investigating the use of a coolant recycling machine that has a potential to reduce the generation of hazardous waste by 19,140 gallons. Implementation, by the generator, of the machine will occur by September, 1992, if feasible.

APPENDIX A

WASTE GENERATION DATA

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

LOW-LEVEL RAD VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
A	1						0.00		0.00	0.00
A	3						0.00		0.00	0.00
A	4						0.00		0.00	0.00
A	5						0.00		0.00	0.00
A	DO						0.00		0.00	0.00
A	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ACT	TOTALS	0.08					0.02		0.08	0.01
ADCM	TOTALS						0.00		0.00	0.00
ADDRA	TOTALS						0.00		0.00	0.00
ADNWT	TOTALS					1.70	0.34		1.70	0.28
ADP	1						0.00		0.00	0.00
ADP	5						0.00		0.00	0.00
ADP	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ADR	TOTALS						0.00		0.00	0.00
AT	1	0.03	0.53				0.11		0.56	0.09
AT	2			0.03			0.01		0.03	0.01
AT	3						0.00		0.00	0.00
AT	4	0.50		4.25			0.95		4.75	0.79
AT	5						0.00		0.00	0.00
AT	6						0.00		0.00	0.00
AT	7	0.17	0.34				0.10		0.51	0.09
AT	8						0.00		0.00	0.00
AT	9						0.00		0.00	0.00
AT	10						0.00		0.00	0.00
AT	DO	0.20		0.17	1.29	14.73	3.28	29.54	45.93	7.66
AT	TOTALS	0.90	0.87	4.45	1.29	14.73	4.45	29.54	51.78	8.63
C	1						0.00		0.00	0.00
C	7						0.00		0.00	0.00
C	DO						0.00		0.00	0.00
C	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHM	1	256.24	23.22				55.89		279.46	46.58
CHM	2	17.57	9.91				5.50		27.48	4.58
CHM	3	1.08					0.22		1.08	0.18
CHM	4	0.17					0.03		0.17	0.03
CHM	5	0.57					0.11		0.57	0.10
CHM	DO						0.00		0.00	0.00
CHM	TOTALS	275.63	33.13	0.00	0.00	0.00	61.75	0.00	308.76	51.46
CLS	1		221.69	131.12	86.66	171.17	122.13	549.73	1160.37	193.40
CLS	2		1.64	53.00		40.30	18.99	77.88	172.82	28.80
CLS	3		1.36	1.70	4.11	8.58	3.15	1.83	17.58	2.93
CLS	4		9.58		8.36	6.94	4.98	73.88	98.76	16.46
CLS	5						0.00	0.85	0.85	0.14
CLS	6		1.36		5.38		1.35		6.74	1.12
CLS	7		0.83		0.42		0.25	22.09	23.34	3.89
CLS	8			0.42			0.08		0.42	0.07
CLS	9						0.00		0.00	0.00

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

LOW-LEVEL RAD VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
CLS	DO		8.04	9.91	1.13	11.04	6.02		30.12	5.02
CLS	TOTALS	0.00	244.50	196.15	106.06	238.03	156.95	726.26	1511.00	251.83
CMS	TOTALS						0.00		0.00	0.00
CNSS	TOTALS						0.00		0.00	0.00
CRM	1						0.00		0.00	0.00
CRM	2						0.00		0.00	0.00
CRM	3						0.00		0.00	0.00
CRM	DO						0.00		0.00	0.00
CRM	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CTR	1						0.00		0.00	0.00
CTR	2	0.62	0.07				0.14		0.69	0.12
CTR	3	20.31	0.53				4.17		20.84	3.47
CTR	4					0.34	0.07		0.34	0.06
CTR	5	8.41	2.50				2.18		10.91	1.82
CTR	7						0.00		0.00	0.00
CTR	8						0.00		0.00	0.00
CTR	9	7.29					1.46		7.29	1.22
CTR	10						0.00		0.00	0.00
CTR	DO	293.11	0.21	1.39		2.83	59.51	0.93	298.52	49.75
CTR	TOTALS	329.74	3.31	1.39	0.00	3.17	67.52	0.98	338.59	56.43
EG&G	TOTALS				0.23		0.05		0.23	0.04
E	1	2.50	0.34				0.57		2.84	0.4
E	2						0.00		0.00	0.00
E	5						0.00		0.00	0.00
E	11	0.01					0.00		0.01	0.00
E	TOTALS	2.51	0.34	0.00	0.00	0.00	0.57	0.00	2.85	0.48
EES	1					0.02	0.00		0.02	0.00
EES	3						0.00		0.00	0.00
EES	4						0.00	0.50	0.50	0.08
EES	5						0.00		0.00	0.00
EES	14						0.00		0.00	0.00
EES	15						0.00		0.00	0.00
EES	DO						0.00	0.60	0.60	0.10
EES	TOTALS	0.00	0.00	0.00	0.00	0.02	0.00	1.10	1.12	0.19
EM	7						0.00	868.42	868.42	144.74
EM	8						0.00	0.28	0.28	0.05
EM	9						0.00	13.15	13.15	2.19
EM	13						0.00	3.96	3.96	0.66
EM	DO						0.00		0.00	0.00
EM	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	885.81	885.81	147.64
ENG	1	49.44				1.58	10.20		51.02	8.50
ENG	2	11.33					2.27		11.33	1.89
ENG	3				7.08		1.42		7.08	1.18
ENG	4	367.61	46.25		21.24		87.02		435.10	72.52
ENG	5		94.25	50.83	144.84	65.83	71.15	45.31	401.06	66.84

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LOW-LEVEL RAD VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
ENG	6			11.61		49.76	12.27	1.42	62.79	10.47
ENG	8						0.00		0.00	0.00
ENG	DO	2.04			14.16		3.24		16.20	2.70
ENG	TOTALS	430.42	140.50	62.44	187.32	117.17	187.57	46.73	984.58	164.10
ERDC	TOTALS						0.00		0.00	0.00
ESS	1		3.00				0.60		3.00	0.50
ESS	3			0.17		0.27	0.09		0.44	0.07
ESS	4	5.21			0.45		1.13		5.66	0.94
ESS	6	0.20					0.04		0.20	0.03
ESS	9	4.25			0.02		0.85		4.27	0.71
ESS	11				0.08		0.02		0.08	0.01
ESS	14					0.62	0.12		0.62	0.10
ESS	15						0.00		0.00	0.00
ESS	DO						0.00		0.00	0.00
ESS	TOTALS	9.66	3.00	0.17	0.55	0.89	2.85	0.00	14.27	2.38
FIN	4						0.00		0.00	0.00
FIN	10						0.00		0.00	0.00
FIN	14						0.00		0.00	0.00
FIN	DO						0.00		0.00	0.00
FIN	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIRE-DEP	TOTALS						0.00		0.00	0.00
HRD	1					1.36	0.27		1.36	0.23
HRD	3						0.00		0.00	0.00
HRD	4						0.00		0.00	0.00
HRD	TOTALS	0.00	0.00	0.00	0.00	1.36	0.27	0.00	1.36	0.23
HS	1						0.00	1.85	1.85	0.31
HS	2						0.00		0.00	0.00
HS	3						0.00		0.00	0.00
HS	4						0.00	0.34	0.34	0.06
HS	5						0.00	17.56	17.56	2.93
HS	11						0.00		0.00	0.00
HS	DO						0.00		0.00	0.00
HS	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	19.75	19.75	3.29
HSE	1	135.13	9.08	16.43	6.08	1.73	33.69		168.45	28.08
HSE	2	0.20	0.14	0.08	0.08		0.10		0.50	0.08
HSE	3						0.00		0.00	0.00
HSE	5	2.39	0.17		0.04	0.57	0.63		3.17	0.53
HSE	6						0.00		0.00	0.00
HSE	7	1957.38	435.26	708.12	1217.52	667.48	997.15		4985.76	830.96
HSE	8	9.57	4.10	21.89	1.95	17.22	10.95		54.73	9.12
HSE	9	2.13	3.47	18.78	1.23	8.62	6.85		34.23	5.71
HSE	10	0.03	4.29	5.66		11.33	4.26		21.31	3.55
HSE	11		13.71	0.40	4.38		3.70		18.49	3.08
HSE	12	46.48	8.55	0.10	5.00		12.03		60.13	10.02
HSE	DO						0.00		0.00	0.00
HSE	TOTALS	2153.31	478.77	771.46	1236.28	706.95	1069.35	0.00	5346.77	891.13

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LOW-LEVEL RAD VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
INC	4	52.59	34.05	57.53	61.20	64.52	53.98	32.95	302.84	50.47
INC	5	31.70	7.97	46.53	50.29	0.79	27.46	23.03	160.31	26.72
INC	7						0.00	0.01	0.01	0.00
INC	11	218.84	168.94	330.26	109.63	300.51	225.64	303.04	1931.22	321.87
INC	DO						0.00		0.00	0.00
INC	TOTALS	303.13	210.96	434.32	221.12	365.82	307.07	359.03	2394.38	399.06
IS	3						0.00		0.00	0.00
IS	4						0.00		0.00	0.00
IS	8						0.00		0.00	0.00
IS	9					0.68	0.14		0.68	0.11
IS	10						0.00		0.00	0.00
IS	11					0.59	0.12		0.59	0.10
IS	12					0.42	0.08		0.42	0.07
IS	DO						0.00		0.00	0.00
IS	TOTALS	0.00	0.00	0.00	0.00	1.69	0.34	0.00	1.69	0.28
IT	4						0.00		0.00	0.00
IT	6		8.50				1.70		8.50	1.42
IT	7				10.00	1.90	2.38		11.90	1.98
IT	DO						0.00		0.00	0.00
IT	TOTALS	0.00	8.50	0.00	10.00	1.90	4.08	0.00	20.40	3.40
J	6					0.28	0.06		0.28	0.05
J	7						0.00	0.85	0.85	0.14
J	8						0.00		0.00	0.00
J	DO					0.45	0.09		0.45	0.08
J	TOTALS	0.00	0.00	0.00	0.00	0.73	0.15	0.85	1.58	0.26
JCI	TOTALS	283.86	374.10	622.47	976.45	715.65	594.51	143.98	3116.51	519.42
LANSCE	TOTALS		13.59	0.57	1.70		3.17	2.39	18.25	3.04
LS	1	22.80	12.12	0.25	1.87		7.41	1.13	38.17	6.36
LS	2			9.14	13.24	6.93	5.86	6.25	35.56	5.93
LS	3	0.11	0.25	0.40			0.15		0.76	0.13
LS	4			0.23		2.27	0.50		2.50	0.42
LS	6	0.10					0.02		0.10	0.02
LS	DO	12.36	9.66	18.00	10.56	43.98	18.91	21.52	116.08	19.35
LS	TOTALS	35.37	22.03	28.02	25.67	53.18	32.85	28.90	193.17	32.19
M	1		1.77		0.04	10.51	2.46		12.32	2.05
M	4	137.31	385.66	162.35	113.47	96.31	179.02	84.43	979.53	163.26
M	6	4.69	40.70	0.03	8.13	22.94	15.30	7.60	84.09	14.02
M	7						0.00		0.00	0.00
M	8		7.00	212.47	106.52	365.74	138.35	160.92	852.65	142.11
M	9	0.21					0.04		0.21	0.04
M	DO						0.00		0.00	0.00
M	TOTALS	142.21	435.13	374.85	228.16	495.50	335.17	252.95	1928.80	321.47
M & H	TOTALS						0.00		0.00	0.00
MAT	1				0.31		0.06		0.31	0.05
MAT	2						0.00		0.00	0.00

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LOW-LEVEL RAD VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
MAT	3						0.00		0.00	0.00
MAT	4				4.81		0.96		4.81	0.80
MAT	8	16.43	13.03	12.74	27.36	12.74	16.46	8.50	90.80	15.13
MAT	14			0.45			0.09		0.45	0.08
MAT	DO					0.07	0.01		0.07	0.01
MAT	TOTALS	16.43	13.03	13.19	32.48	12.81	17.59	8.50	96.44	16.07
MEC	1	74.15	140.79	127.95	57.29	119.24	103.88	127.70	647.12	107.85
MEC	2						0.00		0.00	0.00
MEC	3	10.08					2.02	8.50	18.58	3.10
MEC	4						0.00		0.00	0.00
MEC	5	0.34		4.08		0.06	0.90	1.02	5.50	0.92
MEC	6	2.55	0.28	0.31	0.85	0.85	0.97		4.84	0.81
MEC	8						0.00		0.00	0.00
MEC	9		4.76	12.23	11.33	2.04	6.07		30.36	5.06
MEC	10				1.70		0.34	3.62	5.32	0.89
MEC	DO	0.21		5.44		14.18	3.97		19.83	3.31
MEC	TOTALS	87.33	145.83	150.01	71.17	136.37	118.14	140.84	731.55	121.93
MEE	3			0.21			0.04		0.21	0.04
MEE	4						0.00		0.00	0.00
MEE	5						0.00		0.00	0.00
MEE	9		31.72		61.45		18.63	42.48	135.65	22.61
MEE	10						0.00		0.00	0.00
MEE	11					0.11	0.02		0.11	0.02
MEE	12						0.00		0.00	0.00
MEE	13		3.68	1.53	0.23	21.13	5.31	58.06	84.63	14.11
MEE	DO					0.03	0.01	3.12	3.15	0.53
MEE	TOTALS	0.00	35.40	1.74	61.68	21.27	24.02	103.66	223.75	37.29
MP	1	2.29				0.74	0.61	108.01	111.04	18.51
MP	2	10.00					2.00		10.00	1.67
MP	4						0.00		0.00	0.00
MP	5		22.69		10.87	22.44	11.20	7.08	63.08	10.51
MP	6						0.00		0.00	0.00
MP	7	147.25	436.85	140.94	98.93	1180.12	400.82	153.77	2157.86	359.64
MP	8			0.51		2.13	0.53		2.64	0.44
MP	10				0.11	1.81	0.38		1.92	0.32
MP	11	0.41	1.44	11.98			2.77		13.83	2.31
MP	13	1.70					0.34		1.70	0.28
MP	DO	97.92	42.06	134.55	62.64	354.51	138.34	0.06	691.74	115.29
MP	TOTALS	259.57	503.04	287.98	172.55	1561.75	556.98	268.92	3053.81	508.97
MST	1			7.93			1.59		7.93	1.32
MST	3	50.65	20.16	67.31	23.69	11.84	34.73	66.43	240.08	40.01
MST	4				6.80	19.66	5.29	3.57	30.03	5.01
MST	5	52.25	35.77	50.13	58.57	42.14	47.77	422.95	661.81	110.30
MST	6	333.50	354.76	437.65	422.31	335.63	376.77	379.78	2263.63	377.27
MST	7	8.34	11.33	15.09	54.04	12.53	20.27	8.88	110.21	18.37
MST	8			6.23	83.55		17.96		89.78	14.96
MST	9		25.49				5.10		25.49	4.25
MST	10	256.99	167.77	189.58	637.11	5.83	251.46		1257.28	209.55
MST	11	1.53		23.03	5.03		5.92		29.59	4.93
MST	12	382.18	439.42	546.27	267.24	5.75	328.17		1640.86	273.48
MST	13						0.00		0.00	0.00
MST	14	115.48	47.15	276.63	101.24	689.42	245.98	1.13	1231.05	205.18
MST	17				163.96	13.59	35.51		177.55	29.59
MST	DO				1.19		0.24	150.06	151.25	25.21

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LOW-LEVEL RAD VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
MST	TOTALS	1200.92	1101.85	1619.85	1824.73	1136.39	1376.75	1032.80	7916.54	1319.42
N	1		0.62		5.35	8.09	2.81		14.06	2.34
N	2		139.84	55.56	11.55	89.60	59.31	150.59	447.14	74.52
N	4				0.42	0.33	0.15		0.75	0.13
N	10				0.21		0.04		0.21	0.04
N	DO				0.40		0.08		0.40	0.07
N	TOTALS	0.00	140.46	55.56	17.93	98.02	62.39	150.59	462.56	77.09
NMT	1					24.69	4.94	15.06	39.75	6.63
NMT	2						0.00		0.00	0.00
NMT	3						0.00		0.00	0.00
NMT	4					507.42	101.48	502.00	1009.42	168.24
NMT	5						0.00		0.00	0.00
NMT	6						0.00	2.27	2.27	0.38
NMT	7					629.24	125.85	357.20	986.44	164.41
NMT	8					0.14	0.03		0.14	0.02
NMT	9						0.00		0.00	0.00
NMT	10					4.87	0.97		4.87	0.81
NMT	11					0.11	0.02		0.11	0.02
NMT	17					14.50	2.90		14.50	2.42
NMT	TOTALS	0.00	0.00	0.00	0.00	1180.97	236.19	876.53	2057.50	342.92
OM	TOTALS						0.00		0.00	0.00
OS	1						0.00		0.00	0.00
OS	2	21.69	18.33	2.27	9.86		10.43	38.74	90.89	15.1[illegible]
OS	4					0.68	0.14		0.68	0.[illegible]
OS	5	0.11					0.02		0.11	0.02
OS	8		35.12				7.02		35.12	5.85
OS	10						0.00		0.00	0.00
OS	14				20.74		4.15	7.45	28.19	4.70
OS	DO						0.00		0.00	0.00
OS	TOTALS	21.80	53.45	2.27	30.60	0.68	21.76	46.19	154.99	25.83
P	1			1.25			0.25	0.06	1.31	0.22
P	2					4.00	0.80		4.00	0.67
P	3	0.25		1.14	1.59	0.42	0.68	0.53	3.93	0.66
P	4						0.00		0.00	0.00
P	6						0.00		0.00	0.00
P	7						0.00		0.00	0.00
P	8	0.34				43.85	8.84		44.19	7.37
P	9	48.21	29.55	14.50	7.50	15.24	23.00	14.23	129.23	21.54
P	10	36.46	6.24	41.97	0.51	27.44	22.52	28.47	141.09	23.52
P	12					0.31	0.06		0.31	0.05
P	14	0.17					0.03		0.17	0.03
P	15	0.06				4.08	0.83		4.14	0.69
P	17					25.32	5.06		25.32	4.22
P	DO	0.11				0.17	0.06		0.28	0.05
P	TOTALS	85.60	35.79	58.86	9.60	120.83	62.14	43.29	353.97	59.00
PA	1						0.00		0.00	0.00
PA	2						0.00		0.00	0.00
PA	15						0.00		0.00	0.00
PA	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

LOW-LEVEL RAD VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
PS	TOTALS						0.00		0.00	0.00
Q	1	1.70					0.34		1.70	0.28
Q	2	77.24	41.51				23.75		118.75	19.79
Q	6	0.09					0.02		0.09	0.02
Q	13	1.28					0.26		1.28	0.21
Q	DO						0.00		0.00	0.00
Q	TOTALS	80.31	41.51	0.00	0.00	0.00	24.36	0.00	121.82	20.30
SPRM	TOTALS					0.85	0.17		0.85	0.14
SST	7					0.04	0.01		0.04	0.01
SST	8						0.00		0.00	0.00
SST	9					0.04	0.01		0.04	0.01
SST	11					1.67	0.33		1.67	0.28
SST	DO						0.00		0.00	0.00
SST	TOTALS	0.00	0.00	0.00	0.00	1.75	0.35	0.00	1.75	0.29
T	2						0.00		0.00	0.00
T	7						0.00		0.00	0.00
T	11						0.00		0.00	0.00
T	DO					2.80	0.56		2.80	0.47
T	TOTALS	0.00	0.00	0.00	0.00	2.80	0.56	0.00	2.80	0.47
VWR	TOTALS						0.00		0.00	0.00
WX	1	10.98	0.42			13.72	5.02	6.28	31.40	5.23
WX	3	10.29	2.89	5.78	6.71	3.21	5.78	3.90	32.78	5.46
WX	4	5.38					1.08		5.38	0.90
WX	5	16.54	1.46	18.52	13.20	88.27	27.60	18.52	156.51	26.09
WX	6	5.10					1.02		5.10	0.85
WX	10						0.00		0.00	0.00
WX	11		1.42	3.00	2.05	8.46	2.99	9.97	24.90	4.15
WX	12						0.00		0.00	0.00
WX	DO						0.00		0.00	0.00
WX	TOTALS	48.29	6.19	27.30	21.96	113.66	43.48	38.67	256.07	42.68
X	1					3.40	0.68		3.40	0.57
X	DO					27.19	5.44		27.19	4.53
X	TOTALS	0.00	0.00	0.00	0.00	30.59	6.12	0.00	30.59	5.10
WASTE VOLUME TOTALS BY FY:		5767.07	4045.28	4713.05	5237.53	7137.23		5708.26		

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

TRANSURANIC VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
A	1						0.00		0.00	0.00
A	3						0.00		0.00	0.00
A	4						0.00		0.00	0.00
A	5						0.00		0.00	0.00
A	DO						0.00		0.00	0.00
A	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ACT	TOTALS						0.00		0.00	0.00
ADCM	TOTALS						0.00		0.00	0.00
ADDRA	TOTALS						0.00		0.00	0.00
ADNWT	TOTALS						0.00		0.00	0.00
ADP	1						0.00		0.00	0.00
ADP	5						0.00		0.00	0.00
ADP	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ADR	TOTALS						0.00		0.00	0.00
AT	1						0.00		0.00	0.00
AT	2						0.00		0.00	0.00
AT	3						0.00		0.00	0.00
AT	4						0.00		0.00	0.00
AT	5						0.00		0.00	0.00
AT	6						0.00		0.00	0.00
AT	7						0.00		0.00	0.00
AT	8						0.00		0.00	0.00
AT	9						0.00		0.00	0.00
AT	10						0.00		0.00	0.00
AT	DO						0.00		0.00	0.00
AT	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C	1						0.00		0.00	0.00
C	7						0.00		0.00	0.00
C	DO						0.00		0.00	0.00
C	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHM	1	31.65	17.38				9.81		49.03	8.17
CHM	2						0.00		0.00	0.00
CHM	3						0.00		0.00	0.00
CHM	4						0.00		0.00	0.00
CHM	5						0.00		0.00	0.00
CHM	DO						0.00		0.00	0.00
CHM	TOTALS	31.65	17.38	0.00	0.00	0.00	9.81	0.00	49.03	8.17
CLS	1		15.36	13.50	18.15	17.89	12.98	7.28	72.18	12.03
CLS	2						0.00		0.00	0.00
CLS	3						0.00		0.00	0.00
CLS	4						0.00		0.00	0.00
CLS	5						0.00		0.00	0.00
CLS	6						0.00		0.00	0.00
CLS	7						0.00		0.00	0.00
CLS	8						0.00		0.00	0.00
CLS	9						0.00		0.00	0.00

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

TRANSURANIC VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
ENG	6						0.00		0.00	0.00
ENG	8						0.00		0.00	0.00
ENG	DO						0.00		0.00	0.00
ENG	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ERDC	TOTALS						0.00		0.00	0.00
ESS	1						0.00		0.00	0.00
ESS	3						0.00		0.00	0.00
ESS	4						0.00		0.00	0.00
ESS	6						0.00		0.00	0.00
ESS	9						0.00		0.00	0.00
ESS	11						0.00		0.00	0.00
ESS	14						0.00		0.00	0.00
ESS	15						0.00		0.00	0.00
ESS	DO						0.00		0.00	0.00
ESS	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIN	4						0.00		0.00	0.00
FIN	10						0.00		0.00	0.00
FIN	14						0.00		0.00	0.00
FIN	DO						0.00		0.00	0.00
FIN	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIRE-DEP	TOTALS						0.00		0.00	0.00
HRD	1						0.00		0.00	0.00
HRD	3						0.00		0.00	0.00
HRD	4						0.00		0.00	0.00
HRD	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HS	1						0.00		0.00	0.00
HS	2						0.00		0.00	0.00
HS	3						0.00		0.00	0.00
HS	4						0.00		0.00	0.00
HS	5						0.00		0.00	0.00
HS	11						0.00		0.00	0.00
HS	DO						0.00		0.00	0.00
HS	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HSE	1	0.21	0.20				0.08		0.41	0.07
HSE	2						0.00		0.00	0.00
HSE	3						0.00		0.00	0.00
HSE	5						0.00		0.00	0.00
HSE	6						0.00		0.00	0.00
HSE	7	484.09	27.30	87.87	44.64	34.91	135.76		678.81	113.14
HSE	8						0.00		0.00	0.00
HSE	9						0.00		0.00	0.00
HSE	10						0.00		0.00	0.00
HSE	11						0.00		0.00	0.00
HSE	12						0.00		0.00	0.00
HSE	DO						0.00		0.00	0.00
HSE	TOTALS	484.30	27.50	87.87	44.64	34.91	135.84	0.00	679.22	113.20

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

TRANSURANIC VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
CLS	DO						0.00		0.00	0.00
CLS	TOTALS	0.00	15.36	13.50	18.15	17.89	12.98	7.28	72.18	12.03
CMS	TOTALS						0.00		0.00	0.00
CNSS	TOTALS						0.00		0.00	0.00
CRM							0.00		0.00	0.00
CRM							0.00		0.00	0.00
CRM	3						0.00		0.00	0.00
CRM	DO						0.00		0.00	0.00
CRM	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CTR	1						0.00		0.00	0.00
CTR	2						0.00		0.00	0.00
CTR	3						0.00		0.00	0.00
CTR	4						0.00		0.00	0.00
CTR	5						0.00		0.00	0.00
CTR	7						0.00		0.00	0.00
CTR	8						0.00		0.00	0.00
CTR	9						0.00		0.00	0.00
CTR	10						0.00		0.00	0.00
CTR	DO						0.00		0.00	0.00
CTR	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EG&G	TOTALS	0.00					0.00		0.00	0.00
E	1						0.00		0.00	0.00
E	2						0.00		0.00	0.00
E	5						0.00		0.00	0.00
E	11						0.00		0.00	0.00
E	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EES	1						0.00		0.00	0.00
EES	3						0.00		0.00	0.00
EES	4						0.00		0.00	0.00
EES	5						0.00		0.00	0.00
EES	14						0.00		0.00	0.00
EES	15						0.00		0.00	0.00
EES	DO						0.00		0.00	0.00
EES	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EM	7						0.00	1.90	1.90	0.32
EM	8						0.00		0.00	0.00
EM	9						0.00		0.00	0.00
EM	13						0.00		0.00	0.00
EM	DO						0.00		0.00	0.00
EM	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	1.90	1.90	0.32
ENG	1						0.00		0.00	0.00
ENG	2						0.00		0.00	0.00
ENG	3						0.00		0.00	0.00
ENG	4						0.00		0.00	0.00
ENG	5						0.00		0.00	0.00

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

TRANSURANIC VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
MAT	3						0.00		0.00	0.00
MAT	4						0.00		0.00	0.00
MAT	8						0.00		0.00	0.00
MAT	14						0.00		0.00	0.00
MAT	DO						0.00		0.00	0.00
MAT	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MEC	1						0.00		0.00	0.00
MEC	2						0.00		0.00	0.00
MEC	3						0.00		0.00	0.00
MEC	4						0.00		0.00	0.00
MEC	5						0.00		0.00	0.00
MEC	6						0.00		0.00	0.00
MEC	8						0.00		0.00	0.00
MEC	9						0.00		0.00	0.00
MEC	10						0.00		0.00	0.00
MEC	DO						0.00		0.00	0.00
MEC	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MEE	3						0.00		0.00	0.00
MEE	4						0.00		0.00	0.00
MEE	5						0.00		0.00	0.00
MEE	9						0.00		0.00	0.00
MEE	10						0.00		0.00	0.00
MEE	11						0.00		0.00	0.00
MEE	12						0.00		0.00	0.00
MEE	13						0.00		0.00	0.00
MEE	DO						0.00		0.00	0.00
MEE	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MP	1						0.00		0.00	0.00
MP	2						0.00		0.00	0.00
MP	4						0.00		0.00	0.00
MP	5						0.00		0.00	0.00
MP	6						0.00		0.00	0.00
MP	7						0.00		0.00	0.00
MP	8						0.00		0.00	0.00
MP	10						0.00		0.00	0.00
MP	11						0.00		0.00	0.00
MP	13						0.00		0.00	0.00
MP	DO						0.00		0.00	0.00
MP	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MST	1						0.00		0.00	0.00
MST	3						0.00		0.00	0.00
MST	4						0.00		0.00	0.00
MST	5	5.26	5.37	3.95	4.78	3.33	4.54		22.69	3.78
MST	6						0.00		0.00	0.00
MST	7						0.00		0.00	0.00
MST	8						0.00		0.00	0.00
MST	9						0.00		0.00	0.00
MST	10	291.86	136.60	2.60	1.20	0.60	86.57		432.86	72.14
MST	11		3.17				0.63		3.17	0.53
MST	12	0.20	60.14	101.63	80.55	11.96	50.90		254.48	42.41
MST	13	0.40	0.40				0.16		0.80	0.13
MST	14	2.10	0.31	0.04			0.49		2.45	0.41
MST	17				2.29	25.75	5.61	0.42	28.46	4.74
MST	DO						0.00		0.00	0.00

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

TRANSURANIC VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
INC	4	1.40				1.46	0.57		2.86	0.48
INC	5						0.00		0.00	0.00
INC	7						0.00		0.00	0.00
INC	11	0.20					0.04		0.20	0.03
INC	DO						0.00		0.00	0.00
INC	TOTALS	1.60	0.00	0.00	0.00	1.46	0.61	0.00	3.06	0.51
IS	3						0.00		0.00	0.00
IS	4						0.00		0.00	0.00
IS	8						0.00		0.00	0.00
IS	9						0.00		0.00	0.00
IS	10						0.00		0.00	0.00
IS	11						0.00		0.00	0.00
IS	12						0.00		0.00	0.00
IS	DO						0.00		0.00	0.00
IS	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IT	4						0.00		0.00	0.00
IT	6						0.00		0.00	0.00
IT	7						0.00		0.00	0.00
IT	DO						0.00		0.00	0.00
IT	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
J	6						0.00		0.00	0.00
J	7						0.00		0.00	0.00
J	8						0.00		0.00	0.00
J	DO						0.00		0.00	0.00
J	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JCI	TOTALS						0.00		0.00	0.00
LANSCE	TOTALS						0.00		0.00	0.00
LS	1						0.00		0.00	0.00
LS	2						0.00		0.00	0.00
LS	3						0.00		0.00	0.00
LS	4						0.00		0.00	0.00
LS	6						0.00		0.00	0.00
LS	DO						0.00		0.00	0.00
LS	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M	1						0.00		0.00	0.00
M	4						0.00		0.00	0.00
M	6		16.99	8.72			5.14		25.71	4.29
M	7						0.00		0.00	0.00
M	8						0.00		0.00	0.00
M	9						0.00		0.00	0.00
M	DO						0.00		0.00	0.00
M	TOTALS	0.00	16.99	8.72	0.00	0.00	5.14	0.00	25.71	4.29
M & H	TOTALS						0.00		0.00	0.00
MAT	1						0.00		0.00	0.00
MAT	2						0.00		0.00	0.00

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

TRANSURANIC VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
PS	TOTALS						0.00		0.00	0.00
Q	1						0.00		0.00	0.00
Q	2						0.00		0.00	0.00
Q	6						0.00		0.00	0.00
Q	13						0.00		0.00	0.00
Q	DO						0.00		0.00	0.00
Q	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SPRM	TOTALS						0.00		0.00	0.00
SST	7						0.00		0.00	0.00
SST	8						0.00		0.00	0.00
SST	9						0.00		0.00	0.00
SST	11						0.00		0.00	0.00
SST	DO						0.00		0.00	0.00
SST	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T	2						0.00		0.00	0.00
T	7						0.00		0.00	0.00
T	11						0.00		0.00	0.00
T	DO						0.00		0.00	0.00
T	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VWR	TOTALS						0.00		0.00	0.00
WX	1						0.00		0.00	0.00
WX	3						0.00		0.00	0.00
WX	4						0.00		0.00	0.00
WX	5						0.00		0.00	0.00
WX	6						0.00		0.00	0.00
WX	10						0.00		0.00	0.00
WX	11						0.00		0.00	0.00
WX	12						0.00		0.00	0.00
WX	DO						0.00		0.00	0.00
WX	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
X	1						0.00		0.00	0.00
X	DO						0.00		0.00	0.00
X	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WASTE VOLUME TOTALS BY FY:		817.37	283.22	218.73	151.61	172.61		87.99		

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

TRANSURANIC VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
MST	TOTALS	299.82	205.99	108.22	38.82	41.64	148.90	0.42	744.91	124.15
N	1			0.42			0.08		0.42	0.07
N	2						0.00		0.00	0.00
N	4						0.00		0.00	0.00
N	10						0.00		0.00	0.00
N	DO						0.00		0.00	0.00
N	TOTALS	0.00	0.00	0.42	0.00	0.00	0.08	0.00	0.42	0.07
NMT	1						0.00		0.00	0.00
NMT	2						0.00		0.00	0.00
NMT	3						0.00		0.00	0.00
NMT	4						0.00		0.00	0.00
NMT	5						0.00		0.00	0.00
NMT	6						0.00		0.00	0.00
NMT	7					76.71	15.34	78.39	155.10	25.85
NMT	8						0.00		0.00	0.00
NMT	9						0.00		0.00	0.00
NMT	10						0.00		0.00	0.00
NMT	11						0.00		0.00	0.00
NMT	17						0.00		0.00	0.00
NMT	TOTALS	0.00	0.00	0.00	0.00	76.71	15.34	78.39	155.10	25.85
OM	TOTALS						0.00		0.00	0.00
OS	1						0.00		0.00	0.00
OS	2						0.00		0.00	0.00
OS	4						0.00		0.00	0.00
OS	5						0.00		0.00	0.00
OS	8						0.00		0.00	0.00
OS	10						0.00		0.00	0.00
OS	14						0.00		0.00	0.00
OS	DO						0.00		0.00	0.00
OS	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P	1						0.00		0.00	0.00
P	2						0.00		0.00	0.00
P	3						0.00		0.00	0.00
P	4						0.00		0.00	0.00
P	6						0.00		0.00	0.00
P	7						0.00		0.00	0.00
P	8						0.00		0.00	0.00
P	9						0.00		0.00	0.00
P	10						0.00		0.00	0.00
P	12						0.00		0.00	0.00
P	14						0.00		0.00	0.00
P	15						0.00		0.00	0.00
P	17						0.00		0.00	0.00
P	DO						0.00		0.00	0.00
P	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PA	1						0.00		0.00	0.00
PA	2						0.00		0.00	0.00
PA	15						0.00		0.00	0.00
PA	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS CHEMICAL VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
CLS	DO		20.20	10.43	33.03	7.69	14.27	12.50	83.85	13.98
CLS	TOTALS	0.00	30.62	24.01	104.92	45.34	40.98	97.11	302.00	50.33
CMS	TOTALS						0.00	0.65	0.65	0.11
CNSS	TOTALS						0.00	1.02	1.02	0.17
CRM	1		0.02	0.02		0.03	0.01	0.98	1.05	0.18
CRM	2			0.03		0.15	0.04	1.11	1.29	0.22
CRM	3					0.44	0.09	0.31	0.75	0.13
CRM	DO					0.34	0.07	2.38	2.72	0.45
CRM	TOTALS	0.00	0.02	0.05	0.00	0.96	0.21	4.78	5.81	0.97
CTR	1					4.53	0.91		4.53	0.76
CTR	2	0.62	0.01	0.42		0.14	0.24		1.19	0.20
CTR	3	12.92		0.42	0.38	2.59	3.26		16.31	2.72
CTR	4	0.11	0.04	0.11	0.21	5.11	1.12	0.21	5.79	0.97
CTR	5	8.41	2.50			0.02	2.19		10.93	1.82
CTR	7						0.00	0.42	0.42	0.07
CTR	8			0.21	0.53	2.27	0.60		3.01	0.50
CTR	9	7.29					1.46		7.29	1.22
CTR	10					0.01	0.00		0.01	0.00
CTR	DO	293.09				12.63	61.14	34.85	340.57	56.76
CTR	TOTALS	322.44	2.55	1.16	1.12	27.30	70.91	35.48	390.05	65.01
EG&G	TOTALS		1.30	0.11	0.23	2.05	0.74		3.69	0.62
E	1	2.08					0.42		2.08	0.35
E	2	10.09	0.42				2.10		10.51	1.75
E	5	8.06	3.33				2.28		11.39	1.90
E	11	0.01		0.11			0.02		0.12	0.02
E	TOTALS	20.24	3.75	0.11	0.00	0.00	4.82	0.00	24.10	4.02
EES	1				0.02	1.04	0.21	1.72	2.78	0.46
EES	3				0.05	0.44	0.10	0.60	1.09	0.18
EES	4				0.47	2.63	0.62	3.67	6.77	1.13
EES	5						0.00	0.90	0.90	0.15
EES	14				0.83		0.17		0.83	0.14
EES	15					0.92	0.18	16.62	17.54	2.92
EES	DO					0.21	0.04	0.06	0.27	0.05
EES	TOTALS	0.00	0.00	0.00	1.37	5.24	1.32	23.57	30.18	5.03
EM	7						0.00	916.76	916.76	152.79
EM	8						0.00	2.12	2.12	0.35
EM	9						0.00	3.11	3.11	0.52
EM	13						0.00	0.62	0.62	0.10
EM	DO						0.00	36.76	36.76	6.13
EM	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	959.37	959.37	159.90
ENG	1	23.94					4.79	56.14	80.08	13.35
ENG	2	22.68					4.54	0.03	22.71	3.79
ENG	3					0.29	0.06	0.23	0.52	0.09
ENG	4	19.01	18.50		0.32		7.57		37.83	6.31
ENG	5		63.69	196.76		0.10	52.11	20.72	281.27	46.88

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS CHEMICAL VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
A	1					0.34	0.07		0.34	0.06
A	3						0.00	3.40	3.40	0.57
A	4				0.02	0.24	0.12		0.26	0.04
A	5						0.00	1.70	1.70	0.28
A	DO					0.34	0.07	3.06	3.40	0.57
A	TOTALS	0.00	0.00	0.00	0.02	0.92	0.19	8.16	9.10	1.52
ACT	TOTALS						0.00		0.00	0.00
ADCM	TOTALS				0.21	4.00	0.84		4.21	0.70
ADDRA	TOTALS					3.06	0.61		3.06	0.51
ADNWT	TOTALS		0.21			0.53	0.15	0.68	1.42	0.24
ADP	1					0.02	0.00		0.02	0.00
ADP	5						0.00	0.68	0.68	0.11
ADP	TOTALS	0.00	0.00	0.00	0.00	0.02	0.00	0.68	0.70	0.12
ADR	TOTALS					0.34	0.07		0.34	0.06
AT	1		0.21			0.06	0.05	0.11	0.38	0.06
AT	2		0.42	0.03	0.05	0.07	0.11		0.57	0.10
AT	3	0.02	0.01	0.02		0.02	0.01	0.39	0.46	0.08
AT	4					0.43	0.09	0.12	0.55	0.09
AT	5					0.03	0.01	0.32	0.35	0.06
AT	6	5.83					1.17		5.83	0.97
AT	7	3.09				0.10	0.64	6.66	9.85	1.64
AT	8						0.00	2.24	2.24	0.37
AT	9					1.14	0.23	1.06	2.20	0.37
AT	10					0.63	0.13	0.62	1.25	0.21
AT	DO	9.79	2.08		1.27	2.85	3.20	3.72	19.71	3.29
AT	TOTALS	18.73	2.72	0.05	1.32	5.33	5.63	15.24	43.39	7.23
C	1		1.05	0.45	0.28	0.22	0.40	0.42	2.42	0.40
C	7						0.00	0.02	0.02	0.00
C	DO						0.00	0.12	0.12	0.02
C	TOTALS	0.00	1.05	0.45	0.28	0.22	0.40	0.56	2.56	0.43
CHM	1		0.21				0.04		0.21	0.04
CHM	2						0.00		0.00	0.00
CHM	3						0.00		0.00	0.00
CHM	4	0.53					0.11		0.53	0.09
CHM	5	0.21					0.04		0.21	0.04
CHM	DO	4.57					0.91		4.57	0.76
CHM	TOTALS	5.31	0.21	0.00	0.00	0.00	1.10	0.00	5.52	0.92
CLS	1		0.21	0.12	0.05	0.07	0.09	3.05	3.50	0.58
CLS	2				0.11	0.08	0.04	0.17	0.36	0.06
CLS	3				0.21	10.08	2.06	5.37	15.66	2.61
CLS	4		2.52	0.45	0.51	1.07	0.91	3.01	7.56	1.26
CLS	5		1.58	2.57	0.80	3.06	1.60	2.32	10.33	1.72
CLS	6			0.11	1.21	0.49	0.36	2.06	3.87	0.65
CLS	7		5.68	10.33	68.56	21.86	21.29	68.63	175.06	29.18
CLS	8				0.44	0.94	0.28		1.38	0.23
CLS	9		0.43				0.09		0.43	0.07

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS CHEMICAL VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
INC	4	46.03	23.30	71.32	63.61	9.49	42.75	1.10	214.85	35.81
INC	5	0.53		0.02			0.11	0.22	0.77	0.13
INC	7	0.13	0.42	3.27	18.63	0.36	4.56	0.22	23.03	3.84
INC	11	0.24	1.59	1.86	0.44	10.71	2.97	2.54	17.38	2.90
INC	DO				4.14	0.08	0.84	9.72	13.94	2.32
INC	TOTALS	46.93	25.31	76.47	86.82	20.64	51.23	13.80	269.97	45.00
IS	3				0.16		0.03		0.16	0.03
IS	4						0.00	0.01	0.01	0.00
IS	8						0.00	0.02	0.02	0.00
IS	9	0.01	0.11	1.13		1.82	0.61	19.99	23.06	3.84
IS	10			0.09			0.02		0.09	0.02
IS	11					0.53	0.11		0.53	0.09
IS	12				0.21	0.52	0.15	0.06	0.79	0.13
IS	DO						0.00	0.03	0.03	0.01
IS	TOTALS	0.01	0.11	1.22	0.37	2.87	0.92	20.11	24.69	4.12
IT	4						0.00	0.02	0.02	0.00
IT	6					0.10	0.02	0.25	0.35	0.06
IT	7			0.17		2.01	0.44	0.19	2.37	0.40
IT	DO		0.11	0.11		0.15	0.07	0.25	0.62	0.10
IT	TOTALS	0.00	0.11	0.28	0.00	2.26	0.53	0.71	3.36	0.56
J	6		0.05				0.01		0.05	0.01
J	7					0.01	0.00		0.01	0.00
J	8				0.31		0.06	4.49	4.80	0.80
J	DO					2.00	0.40	1.18	3.18	0.53
J	TOTALS	0.00	0.05	0.00	0.31	2.01	0.47	5.67	8.04	1.34
JCI	TOTALS	262.53	456.97	486.96	901.14	637.64	549.05	543.92	3289.16	548.19
LANSCE	TOTALS		1.87	0.11	0.75	4.47	1.44	1.13	8.33	1.39
LS	1	4.47	0.27	0.06	0.28		1.02	0.53	5.61	0.94
LS	2			0.02	0.55	0.48	0.21	1.09	2.14	0.36
LS	3	0.11	0.12	0.34	0.80	0.50	0.37	0.45	2.32	0.39
LS	4					3.36	0.67	1.42	4.78	0.80
LS	6						0.00		0.00	0.00
LS	DO	1.67		3.64	18.18	10.46	6.79	0.12	34.07	5.68
LS	TOTALS	6.25	0.39	4.06	19.81	14.80	9.06	3.61	48.92	8.15
M	1	4.34	1.06	2.08	3.86	1.67	2.60	40.51	53.52	8.92
M	4	7.57	3.22	0.20	6.65	5.03	4.53	6.48	29.15	4.86
M	6	1.86	1.46	0.45	80.91	47.37	26.41	71.12	203.17	33.86
M	7	1.02	3.75	4.79	14.99	12.25	7.36	22.65	59.45	9.91
M	8		0.42	0.42	26.66	25.78	10.66	1.70	54.98	9.16
M	9	8.76			0.11	2.17	2.21	2.63	13.67	2.28
M	DO		0.14			0.37	0.10	2.84	3.35	0.56
M	TOTALS	23.55	10.05	7.94	133.18	94.64	53.87	147.93	417.29	69.55
M & H	TOTALS				0.66	2.44	0.62	0.57	3.67	0.61
MAT	1	7.70	1.59	0.21	0.07	0.06	1.93		9.63	1.61
MAT	2				0.64	0.03	0.13	2.11	2.78	0.46

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS CHEMICAL VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
ENG	6		19.99	0.77	0.28	0.96	4.40	0.62	22.62	3.77
ENG	8					0.62	0.12	1.61	2.23	0.37
ENG	DO	2.04					0.41		2.04	0.34
ENG	TOTALS	67.67	102.18	197.53	0.60	1.97	73.99	79.35	449.30	74.88
ERDC	TOTALS					0.13	0.03	0.61	0.74	0.12
ESS	1	0.11	0.02	0.03	0.84	0.11	0.22		1.11	0.19
ESS	3				0.79	0.26	0.21		1.05	0.18
ESS	4	0.21	1.57	3.98	0.32		1.22		6.08	1.01
ESS	6	0.20					0.04		0.20	0.03
ESS	9			0.08	0.02		0.02		0.10	0.02
ESS	11	0.29	2.93	1.27	0.44	0.28	1.04		5.21	0.87
ESS	14				0.62		0.12		0.62	0.10
ESS	15						0.00		0.00	0.00
ESS	DO			0.21			0.04		0.21	0.04
ESS	TOTALS	0.81	4.52	5.57	3.03	0.65	2.92	0.00	14.58	2.43
FIN	4						0.00	0.68	0.68	0.11
FIN	10					0.01	0.00		0.01	0.00
FIN	14						0.00	0.34	0.34	0.06
FIN	DO						0.00	0.68	0.68	0.11
FIN	TOTALS	0.00	0.00	0.00	0.00	0.01	0.00	1.70	1.71	0.29
FIRE-DEP	TOTALS						0.00	0.03	0.03	0.01
HRD	1					1.36	0.27		1.36	0.23
HRD	3					0.40	0.08		0.40	0.07
HRD	4						0.00	0.01	0.01	0.00
HRD	TOTALS	0.00	0.00	0.00	0.00	1.76	0.35	0.01	1.77	0.30
HS	1						0.00	0.91	0.91	0.15
HS	2						0.00	1.14	1.14	0.19
HS	3						0.00	0.02	0.02	0.00
HS	4						0.00	0.14	0.14	0.02
HS	5						0.00	0.73	0.73	0.12
HS	11						0.00	0.07	0.07	0.01
HS	DO						0.00	6.53	6.53	1.09
HS	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	9.54	9.54	1.59
HSE	1	0.11	0.41	0.32	0.34	1.82	0.60		3.00	0.50
HSE	2	0.20	0.14	0.08	0.08	0.09	0.12		0.59	0.10
HSE	3						0.00		0.00	0.00
HSE	5	0.03	0.55	0.08		0.04	0.14		0.70	0.12
HSE	6				0.05		0.01		0.05	0.01
HSE	7	70.23	359.87	329.37	682.70	610.64	410.56		2052.81	342.14
HSE	8	0.28		19.62	53.49	54.86	25.65		128.25	21.38
HSE	9	0.97	0.19	3.34	1.81	1.11	1.48		7.42	1.24
HSE	10						0.00		0.00	0.00
HSE	11		0.24	2.46	0.61	0.03	0.67		3.34	0.56
HSE	12		0.12				0.02		0.12	0.02
HSE	DO			0.72		0.11	0.17		0.83	0.14
HSE	TOTALS	71.82	361.52	355.99	739.08	668.70	439.42	0.00	2197.11	366.19

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS CHEMICAL VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
MST	TOTALS	29.66	23.00	31.58	31.44	39.95	31.13	53.31	208.94	34.82
N	1					2.83	0.57	0.88	3.71	0.62
N	2			7.34	0.62	5.77	2.75	1.41	15.14	2.52
N	4				0.43	0.04	0.09		0.47	0.08
N	10				0.21		0.04		0.21	0.04
N	DO				0.13		0.03	1.08	1.21	0.20
N	TOTALS	0.00	0.00	7.34	1.39	8.64	3.47	3.37	20.74	3.46
NMT	1					0.34	0.07	1.75	2.09	0.35
NMT	2					0.31	0.06	0.63	0.94	0.16
NMT	3					1.20	0.24	1.08	2.28	0.38
NMT	4						0.00		0.00	0.00
NMT	5					0.03	0.01	0.11	0.14	0.02
NMT	6						0.00	0.04	0.04	0.01
NMT	7					2.68	0.54	3.66	6.34	1.06
NMT	8					1.36	0.27	5.28	6.64	1.11
NMT	9						0.00	0.01	0.01	0.00
NMT	10						0.00		0.00	0.00
NMT	11						0.00		0.00	0.00
NMT	17						0.00		0.00	0.00
NMT	TOTALS	0.00	0.00	0.00	0.00	5.92	1.18	12.56	18.48	3.08
OM	TOTALS						0.00	0.08	0.08	0.01
OS	1						0.00		0.00	0.00
OS	2					1.87	0.37	1.36	3.23	0.54
OS	4					0.61	0.12	0.03	0.64	0.11
OS	5						0.00		0.00	0.00
OS	8				0.05	3.54	0.72	9.20	12.79	2.13
OS	10						0.00	0.51	0.51	0.09
OS	14				0.11	0.04	0.03		0.15	0.03
OS	DO					0.26	0.05	3.02	3.28	0.55
OS	TOTALS	0.00	0.00	0.00	0.16	6.32	1.30	14.12	20.60	3.43
P	1			2.08		1.28	0.67	1.71	5.07	0.85
P	2					0.01	0.00		0.01	0.00
P	3	0.32	12.42			0.22	2.59	0.01	12.97	2.16
P	4	0.21				0.88	0.22	1.52	2.61	0.44
P	6					0.24	0.05		0.24	0.04
P	7	2.02					0.40		2.02	0.34
P	8	2.08					0.42		2.08	0.35
P	9	0.01	4.64			0.28	0.99	0.84	5.77	0.96
P	10	0.01	0.03		0.83	1.66	0.51	2.54	5.07	0.85
P	12	0.01					0.00		0.01	0.00
P	14	0.30	0.01		0.21	0.64	0.23	1.76	2.92	0.49
P	15		0.21		0.27	4.20	0.94	2.50	7.18	1.20
P	17					0.03	0.01		0.03	0.01
P	DO						0.00	0.68	0.68	0.11
P	TOTALS	4.96	17.31	2.08	1.31	9.44	7.02	11.56	46.66	7.78
PA	1			0.08			0.02		0.08	0.01
PA	2						0.00	0.01	0.01	0.00
PA	15	0.01					0.00		0.01	0.00
PA	TOTALS	0.01	0.00	0.08	0.00	0.00	0.02	0.01	0.10	0.02

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS CHEMICAL VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
MAT	3						0.00	0.02	0.02	0.00
MAT	4						0.00		0.00	0.00
MAT	8						0.00		0.00	0.00
MAT	14	0.42	0.43	1.04	1.17	1.13	0.84	0.77	4.96	0.83
MAT	DO					0.21	0.04		0.21	0.04
MAT	TOTALS	8.12	2.02	1.25	1.88	1.43	2.94	2.90	17.60	2.93
MEC	1	15.25	4.41	5.00	4.30	7.86	7.36	8.70	45.52	7.59
MEC	2	0.01					0.00		0.01	0.00
MEC	3	10.08	4.80	25.91	68.95	66.12	35.17	124.81	300.67	50.11
MEC	4						0.00	0.68	0.68	0.11
MEC	5	0.22	14.65	6.17	12.47	3.04	7.31	1.50	38.05	6.34
MEC	6		1.14	1.26	0.85	1.01	0.85	0.44	4.70	0.78
MEC	8		0.42		0.05	0.23	0.14	0.23	0.93	0.16
MEC	9		1.74	0.16	1.19	1.77	0.97	0.87	5.73	0.96
MEC	10		11.62	16.02	11.63	10.97	10.05	7.53	57.77	9.63
MEC	DO	0.21	1.66	0.62	0.42	0.02	0.59	0.70	3.63	0.61
MEC	TOTALS	25.77	40.44	55.14	99.86	91.02	62.45	145.46	457.69	76.28
MEE	3		0.01				0.00	1.25	1.26	0.21
MEE	4					2.01	0.40	4.42	6.43	1.07
MEE	5					0.01	0.00		0.01	0.00
MEE	9						0.00	0.03	0.03	0.01
MEE	10						0.00	0.68	0.68	0.11
MEE	11		0.08	0.26	0.58	0.45	0.27	0.65	2.02	0.34
MEE	12		0.02	0.13			0.03	0.01	0.16	0.03
MEE	13		0.81			2.79	0.72	0.66	4.26	0.71
MEE	DO					0.01	0.00	3.13	3.14	0.52
MEE	TOTALS	0.00	0.92	0.39	0.58	5.27	1.43	10.83	17.99	3.00
MP	1	2.29					0.46		2.29	0.38
MP	2						0.00		0.00	0.00
MP	4					0.04	0.01	0.05	0.09	0.02
MP	5		0.08		0.17	2.08	0.47	1.58	3.91	0.65
MP	6				0.26	0.02	0.06	0.01	0.29	0.05
MP	7		12.37	0.83	0.76	29.78	8.75	0.57	44.31	7.39
MP	8	0.61	1.56	2.52	2.94	6.72	2.87	3.31	17.66	2.94
MP	10						0.00	0.02	0.02	0.00
MP	11	0.41					0.08		0.41	0.07
MP	13						0.00		0.00	0.00
MP	DO	10.92	1.70	1.39	1.34	3.92	3.85	2.06	21.33	3.56
MP	TOTALS	14.23	15.71	4.74	5.47	42.56	16.54	7.60	90.31	15.05
MST	1						0.00		0.00	0.00
MST	3	0.97		8.00	0.09	0.33	1.88	1.40	10.79	1.80
MST	4					7.09	1.42	1.58	8.67	1.45
MST	5	0.02	0.02			0.50	0.11	0.72	1.26	0.21
MST	6	13.77	3.66	10.04	6.65	29.29	12.68	10.06	73.47	12.25
MST	7	7.16	6.18	1.97	13.92	1.97	6.24	10.31	41.51	6.92
MST	8	0.23	0.32	5.05	8.43		2.81		14.03	2.34
MST	9						0.00		0.00	0.00
MST	10						0.00		0.00	0.00
MST	11	1.12	0.23		0.74		0.42		2.09	0.35
MST	12	4.87	12.25	3.95	1.53		4.52		22.60	3.77
MST	13	1.43	0.34	1.25	0.06	0.02	0.62		3.10	0.52
MST	14			1.32		0.75	0.41		2.07	0.35
MST	17				0.02		0.00		0.02	0.00
MST	DO	0.09					0.02	29.24	29.33	4.89

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS/RADIOACTIVE MIXED VOLUMES -m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
A	1						0.00		0.00	0.00
A	3						0.00		0.00	0.00
A	4						0.00		0.00	0.00
A	5						0.00		0.00	0.00
A	DO						0.00		0.00	0.00
A	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ACT	TOTALS						0.00		0.00	0.00
ADCM	TOTALS						0.00		0.00	0.00
ADDRA	TOTALS						0.00		0.00	0.00
ADNWT	TOTALS						0.00		0.00	0.00
ADP	1						0.00		0.00	0.00
ADP	5						0.00		0.00	0.00
ADP	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ADR	TOTALS						0.00		0.00	0.00
AT	1						0.00		0.00	0.00
AT	2						0.00		0.00	0.00
AT	3						0.00		0.00	0.00
AT	4						0.00		0.00	0.00
AT	5						0.00		0.00	0.00
AT	6						0.00		0.00	0.00
AT	7						0.00		0.00	0.00
AT	8						0.00		0.00	0.00
AT	9						0.00		0.00	0.00
AT	10						0.00		0.00	0.00
AT	DO	0.93				0.21	0.23		1.14	0.19
AT	TOTALS	0.93	0.00	0.00	0.00	0.21	0.23	0.00	1.14	0.19
C	1						0.00		0.00	0.00
C	7						0.00		0.00	0.00
C	DO						0.00		0.00	0.00
C	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CHM	1						0.00		0.00	0.00
CHM	2						0.00		0.00	0.00
CHM	3						0.00		0.00	0.00
CHM	4						0.00		0.00	0.00
CHM	5						0.00		0.00	0.00
CHM	DO						0.00		0.00	0.00
CHM	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CLS	1		0.66	0.23	0.46	0.77	0.42	0.02	2.14	0.36
CLS	2						0.00		0.00	0.00
CLS	3					0.62	0.12		0.62	0.10
CLS	4					0.22	0.04	0.08	0.30	0.05
CLS	5						0.00		0.00	0.00
CLS	6		0.11				0.02		0.11	0.02
CLS	7		0.42	0.62			0.21	1.51	2.55	0.43
CLS	8				0.21		0.04		0.21	0.04
CLS	9						0.00		0.00	0.00

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS CHEMICAL VOLUMES - m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
PS	TOTALS						0.00	0.02	0.02	0.00
Q	1	0.38					0.08		0.38	0.06
Q	2	0.14	0.42				0.11		0.56	0.09
Q	6	0.10					0.02		0.10	0.02
Q	13	0.05					0.01		0.05	0.01
Q	DO	0.90					0.18		0.90	0.15
Q	TOTALS	1.57	0.42	0.00	0.00	0.00	0.40	0.00	1.99	0.33
SPRM	TOTALS						0.00		0.00	0.00
SST	7					0.13	0.03	0.06	0.19	0.03
SST	8					0.03	0.01	0.05	0.08	0.01
SST	9					0.01	0.00	0.03	0.04	0.01
SST	11				0.65	1.92	0.51	1.56	4.13	0.69
SST	DO						0.00	0.02	0.02	0.00
SST	TOTALS	0.00	0.00	0.00	0.65	2.09	0.55	1.72	4.46	0.74
T	2						0.00	1.36	1.36	0.23
T	7						0.00		0.00	0.00
T	11						0.00		0.00	0.00
T	DO					11.45	2.29	6.12	17.57	2.93
T	TOTALS	0.00	0.00	0.00	0.00	11.45	2.29	7.48	18.93	3.16
VWR	TOTALS		0.62	0.02		0.47	0.22	0.09	1.20	0.20
WX	1				0.21	1.41	0.32	7.61	9.23	1.54
WX	3	58.86	102.26	63.53	106.37	150.10	96.22	170.16	651.28	108.55
WX	4	5.38	0.21				1.12		5.59	0.93
WX	5		0.68	0.21		10.50	2.28	7.96	19.35	3.23
WX	6						0.00		0.00	0.00
WX	10	0.10					0.02		0.10	0.02
WX	11				0.05	0.10	0.03	0.85	1.00	0.17
WX	12	0.35	47.91	83.16	51.41	39.71	44.51	4.67	227.21	37.87
WX	DO					0.01	0.00		0.01	0.00
WX	TOTALS	64.69	151.06	146.90	158.04	201.83	144.50	191.25	913.77	152.30
X	1				3.48		0.70		3.48	0.58
X	DO				0.24	30.64	6.18	11.62	42.50	7.08
X	TOTALS	0.00	0.00	0.00	3.72	30.64	6.87	11.62	45.98	7.66
WASTE VOLUME TOTALS BY FY:		995.30	1257.01	1411.59	2299.72	2007.33		2449.97		

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS/RADIOACTIVE MIXED VOLUMES -m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
ENG	6						0.00		0.00	0.00
ENG	8						0.00		0.00	0.00
ENG	DO						0.00		0.00	0.00
ENG	TOTALS	0.00	0.00	0.00	0.00	5.71	1.14	0.00	5.71	0.95
ERDC	TOTALS						0.00		0.00	0.00
ESS	1						0.00		0.00	0.00
ESS	3						0.00		0.00	0.00
ESS	4						0.00		0.00	0.00
ESS	6						0.00		0.00	0.00
ESS	9						0.00		0.00	0.00
ESS	11				0.09		0.02		0.09	0.02
ESS	14						0.00		0.00	0.00
ESS	15						0.00		0.00	0.00
ESS	DO						0.00		0.00	0.00
ESS	TOTALS	0.00	0.00	0.00	0.09	0.00	0.02	0.00	0.09	0.02
FIN	4						0.00		0.00	0.00
FIN	10						0.00		0.00	0.00
FIN	14						0.00		0.00	0.00
FIN	DO						0.00		0.00	0.00
FIN	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FIRE-DEP	TOTALS						0.00		0.00	0.00
HRD	1						0.00		0.00	0.00
HRD	3						0.00		0.00	0.00
HRD	4						0.00		0.00	0.00
HRD	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HS	1						0.00	3.88	3.88	0.65
HS	2						0.00		0.00	0.00
HS	3						0.00		0.00	0.00
HS	4						0.00	1.14	1.14	0.19
HS	5						0.00		0.00	0.00
HS	11						0.00		0.00	0.00
HS	DO						0.00		0.00	0.00
HS	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	5.02	5.02	0.84
HSE	1	2.27	2.81	5.70	5.98	8.44	5.04		25.20	4.20
HSE	2			0.65			0.13		0.65	0.11
HSE	3					0.42	0.08		0.42	0.07
HSE	5						0.00		0.00	0.00
HSE	6						0.00		0.00	0.00
HSE	7	0.95	206.91	66.77	83.76	124.70	96.62		483.09	80.52
HSE	8		0.32	0.23			0.11		0.55	0.09
HSE	9	0.30	0.08	1.03	0.80	0.93	0.63		3.14	0.52
HSE	10			0.12			0.02		0.12	0.02
HSE	11				1.06	0.38	0.29		1.44	0.24
HSE	12						0.00		0.00	0.00
HSE	DO						0.00		0.00	0.00
HSE	TOTALS	3.52	210.12	74.50	91.60	134.87	102.92	0.00	514.61	85.77

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS/RADIOACTIVE MIXED VOLUMES -m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
CLS	DO					0.24	0.05		0.24	0.04
CLS	TOTALS	0.00	1.19	0.85	0.67	1.85	0.91	1.61	6.17	1.03
CMS	TOTALS						0.00		0.00	0.00
CNSS	TOTALS						0.00		0.00	0.00
CRM	1						0.00		0.00	0.00
CRM	2						0.00		0.00	0.00
CRM	3						0.00		0.00	0.00
CRM	DO						0.00		0.00	0.00
CRM	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CTR	1						0.00		0.00	0.00
CTR	2		0.07				0.01		0.07	0.01
CTR	3		0.53				0.11		0.53	0.09
CTR	4						0.00		0.00	0.00
CTR	5						0.00		0.00	0.00
CTR	7						0.00		0.00	0.00
CTR	8						0.00		0.00	0.00
CTR	9						0.00		0.00	0.00
CTR	10						0.00		0.00	0.00
CTR	DO		0.21	1.39			0.32	0.97	2.57	0.43
CTR	TOTALS	0.00	0.81	1.39	0.00	0.00	0.44	0.97	3.17	0.53
EG&G	TOTALS		0.42				0.08		0.42	0.07
E	1						0.00		0.00	0.00
E	2						0.00		0.00	0.00
E	5						0.00		0.00	0.00
E	11						0.00		0.00	0.00
E	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EES	1						0.00		0.00	0.00
EES	3					0.11	0.02		0.11	0.02
EES	4						0.00	0.50	0.50	0.08
EES	5						0.00		0.00	0.00
EES	14					1.74	0.35		1.74	0.29
EES	15						0.00		0.00	0.00
EES	DO						0.00		0.00	0.00
EES	TOTALS	0.00	0.00	0.00	0.00	1.85	0.37	0.50	2.35	0.39
EM	7						0.00	73.26	73.26	12.21
EM	8						0.00		0.00	0.00
EM	9						0.00	1.21	1.21	0.20
EM	13						0.00		0.00	0.00
EM	DO						0.00	2.69	2.69	0.45
EM	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	77.16	77.16	12.86
ENG	1					1.46	0.29		1.46	0.24
ENG	2						0.00		0.00	0.00
ENG	3						0.00		0.00	0.00
ENG	4						0.00		0.00	0.00
ENG	5					4.25	0.85		4.25	0.71

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS/RADIOACTIVE MIXED VOLUMES -m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
MAT	3						0.00		0.00	0.00
MAT	4						0.00		0.00	0.00
MAT	8						0.00		0.00	0.00
MAT	14						0.00		0.00	0.00
MAT	DO						0.00		0.00	0.00
MAT	TOTALS	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.03	0.01
MEC	1		5.82	11.69	8.23	9.71	7.09	10.96	46.41	7.74
MEC	2						0.00		0.00	0.00
MEC	3						0.00		0.00	0.00
MEC	4						0.00	0.01	0.01	0.00
MEC	5		0.62				0.12		0.62	0.10
MEC	6						0.00	0.06	0.06	0.01
MEC	8						0.00		0.00	0.00
MEC	9		2.08	2.82	2.91	7.71	3.10	2.83	18.35	3.06
MEC	10		0.42				0.08	1.33	1.75	0.29
MEC	DO						0.00		0.00	0.00
MEC	TOTALS	0.00	8.94	14.51	11.14	17.42	10.40	15.19	67.20	11.20
MEE	3						0.00	0.13	0.13	0.02
MEE	4						0.00		0.00	0.00
MEE	5						0.00		0.00	0.00
MEE	9						0.00	0.26	0.26	0.04
MEE	10						0.00		0.00	0.00
MEE	11				0.02		0.00		0.02	0.00
MEE	12						0.00		0.00	0.00
MEE	13						0.00	0.57	0.57	0.10
MEE	DO						0.00		0.00	0.00
MEE	TOTALS	0.00	0.00	0.00	0.02	0.00	0.00	0.96	0.98	0.16
MP	1						0.00		0.00	0.00
MP	2			0.21			0.04		0.21	0.04
MP	4				0.02		0.00		0.02	0.00
MP	5					0.21	0.04		0.21	0.04
MP	6						0.00		0.00	0.00
MP	7				0.62	33.62	6.85		34.24	5.71
MP	8						0.00	0.11	0.11	0.02
MP	10						0.00		0.00	0.00
MP	11		1.04	11.98			2.60		13.02	2.17
MP	13						0.00		0.00	0.00
MP	DO				0.06		0.01		0.06	0.01
MP	TOTALS	0.00	1.04	12.19	0.70	33.83	9.55	0.11	47.87	7.98
MST	1						0.00		0.00	0.00
MST	3		0.02	0.34	0.53	0.46	0.27	0.69	2.04	0.34
MST	4						0.00		0.00	0.00
MST	5						0.00	14.05	14.05	2.34
MST	6			0.42	0.64	15.95	3.40	0.47	17.48	2.91
MST	7			1.38	2.29	0.21	0.78	0.05	3.93	0.66
MST	8						0.00		0.00	0.00
MST	9						0.00		0.00	0.00
MST	10						0.00		0.00	0.00
MST	11			0.11			0.02		0.11	0.02
MST	12	0.23	2.21	4.90	7.25		2.92		14.59	2.43
MST	13						0.00		0.00	0.00
MST	14			0.21	1.00	0.62	0.37		1.83	0.31
MST	17				4.52	0.62	1.03		5.14	0.86
MST	DO						0.00	0.04	0.04	0.01

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS/RADIOACTIVE MIXED VOLUMES -m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
INC	4	0.23	0.83	0.42	0.21	0.47	0.43	0.95	3.11	0.52
INC	5				1.48	0.62	0.42	0.83	2.93	0.49
INC	7						0.00	0.01	0.01	0.00
INC	11	0.23	0.65	1.93		7.10	1.98	3.96	13.87	2.31
INC	DO						0.00		0.00	0.00
INC	TOTALS	0.46	1.48	2.35	1.69	8.19	2.83	5.75	19.92	3.32
IS	3						0.00		0.00	0.00
IS	4					0.57	0.11		0.57	0.10
IS	8						0.00		0.00	0.00
IS	9						0.00		0.00	0.00
IS	10						0.00		0.00	0.00
IS	11						0.00		0.00	0.00
IS	12						0.00		0.00	0.00
IS	DO						0.00		0.00	0.00
IS	TOTALS	0.00	0.00	0.00	0.00	0.57	0.11	0.00	0.57	0.10
IT	4						0.00		0.00	0.00
IT	6						0.00		0.00	0.00
IT	7						0.00		0.00	0.00
IT	DO						0.00		0.00	0.00
IT	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
J	6						0.00		0.00	0.00
J	7						0.00		0.00	0.00
J	8						0.00		0.00	0.00
J	DO						0.00		0.00	0.00
J	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JCI	TOTALS	0.21	10.72	263.97	741.39	68.01	216.86	2.52	1086.82	181.14
LANSCE	TOTALS						0.00		0.00	0.00
LS	1						0.00	0.23	0.23	0.04
LS	2						0.00	0.24	0.24	0.04
LS	3	0.66	0.11	4.35	5.69	1.15	2.39	0.59	12.55	2.09
LS	4					0.61	0.12	0.71	1.32	0.22
LS	6						0.00		0.00	0.00
LS	DO		1.37	0.23			0.32		1.60	0.27
LS	TOTALS	0.66	1.48	4.58	5.69	1.76	2.83	1.77	15.94	2.66
M	1					5.70	1.14		5.70	0.95
M	4		0.11	0.08		0.11	0.06	0.42	0.72	0.12
M	6		0.21		0.20		0.08	0.11	0.52	0.09
M	7		0.21	0.21			0.08		0.42	0.07
M	8		0.83		0.95	1.70	0.70	2.54	6.02	1.00
M	9						0.00		0.00	0.00
M	DO						0.00		0.00	0.00
M	TOTALS	0.00	1.36	0.29	1.15	7.51	2.06	3.07	13.38	2.23
M & H	TOTALS					0.68	0.14		0.68	0.11
MAT	1					0.03	0.01		0.03	0.01
MAT	2						0.00		0.00	0.00

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS/RADIOACTIVE MIXED VOLUMES -m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
PS	TOTALS						0.00		0.00	0.00
Q	1						0.00		0.00	0.00
Q	2						0.00		0.00	0.00
Q	6						0.00		0.00	0.00
Q	13						0.00		0.00	0.00
Q	DO						0.00		0.00	0.00
Q	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SPRM	TOTALS						0.00		0.00	0.00
SST	7						0.00		0.00	0.00
SST	8						0.00		0.00	0.00
SST	9						0.00		0.00	0.00
SST	11						0.00		0.00	0.00
SST	DO						0.00		0.00	0.00
SST	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T	2						0.00		0.00	0.00
T	7						0.00		0.00	0.00
T	11						0.00		0.00	0.00
T	DO						0.00		0.00	0.00
T	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VWR	TOTALS						0.00		0.00	0.00
WX	1	2.08		0.11		5.41	1.52	1.47	9.07	1.51
WX	3					1.03	0.21		1.03	0.17
WX	4						0.00		0.00	0.00
WX	5	0.34			0.74		0.22	0.34	1.42	0.24
WX	6						0.00		0.00	0.00
WX	10						0.00		0.00	0.00
WX	11	0.11				2.50	0.52		2.61	0.44
WX	12						0.00		0.00	0.00
WX	DO						0.00		0.00	0.00
WX	TOTALS	2.53	0.00	0.11	0.74	8.94	2.46	1.81	14.13	2.36
X	1						0.00		0.00	0.00
X	DO						0.00		0.00	0.00
X	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WASTE VOLUME TOTALS BY FY:		8.54	240.00	382.83	872.67	323.49		151.18		

Waste Minimization Baseline Data
FY 1986 - FY 1991 Waste Volumes Managed by EM-7

HAZARDOUS/RADIOACTIVE MIXED VOLUMES -m3

DIVISION NAME	GROUP NUMBER	FY86	FY87	FY88	FY89	FY90	5-YEAR AVERAGES	FY91	6-YEAR TOTALS	6-YEAR AVERAGES
MST	TOTALS	0.23	2.23	7.36	16.23	17.86	8.78	15.30	59.21	9.87
N	1					8.50	1.70		8.50	1.42
N	2			0.11			0.02	0.11	0.22	0.04
N	4						0.00		0.00	0.00
N	10						0.00		0.00	0.00
N	DO						0.00		0.00	0.00
N	TOTALS	0.00	0.00	0.11	0.00	8.50	1.72	0.11	8.72	1.45
NMT	1					0.11	0.02	0.11	0.22	0.04
NMT	2					0.57	0.11	0.01	0.58	0.10
NMT	3						0.00		0.00	0.00
NMT	4						0.00		0.00	0.00
NMT	5						0.00		0.00	0.00
NMT	6						0.00		0.00	0.00
NMT	7					2.88	0.58	5.06	7.94	1.32
NMT	8						0.00		0.00	0.00
NMT	9					0.05	0.01		0.05	0.01
NMT	10						0.00		0.00	0.00
NMT	11						0.00		0.00	0.00
NMT	17						0.00		0.00	0.00
NMT	TOTALS	0.00	0.00	0.00	0.00	3.61	0.72	5.18	8.79	1.47
OM	TOTALS						0.00		0.00	0.00
OS	1						0.00		0.00	0.00
OS	2						0.00	13.31	13.31	2.22
OS	4						0.00		0.00	0.00
OS	5						0.00		0.00	0.00
OS	8						0.00		0.00	0.00
OS	10						0.00		0.00	0.00
OS	14				0.02	0.11	0.03		0.13	0.02
OS	DO						0.00		0.00	0.00
OS	TOTALS	0.00	0.00	0.00	0.02	0.11	0.03	13.31	13.44	2.24
P	1						0.00		0.00	0.00
P	2						0.00		0.00	0.00
P	3						0.00	0.62	0.62	0.10
P	4				0.21		0.04		0.21	0.04
P	6				0.91	1.37	0.46		2.28	0.38
P	7						0.00		0.00	0.00
P	8					0.17	0.03		0.17	0.03
P	9		0.21	0.62	0.42	0.42	0.33	0.21	1.88	0.31
P	10						0.00	0.01	0.01	0.00
P	12						0.00		0.00	0.00
P	14						0.00		0.00	0.00
P	15						0.00		0.00	0.00
P	17						0.00		0.00	0.00
P	DO					0.02	0.00		0.02	0.00
P	TOTALS	0.00	0.21	0.62	1.54	1.98	0.87	0.84	5.19	0.87
PA	1						0.00		0.00	0.00
PA	2						0.00		0.00	0.00
PA	15						0.00		0.00	0.00
PA	TOTALS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX B

BASELINE AND DATA GRAPHS

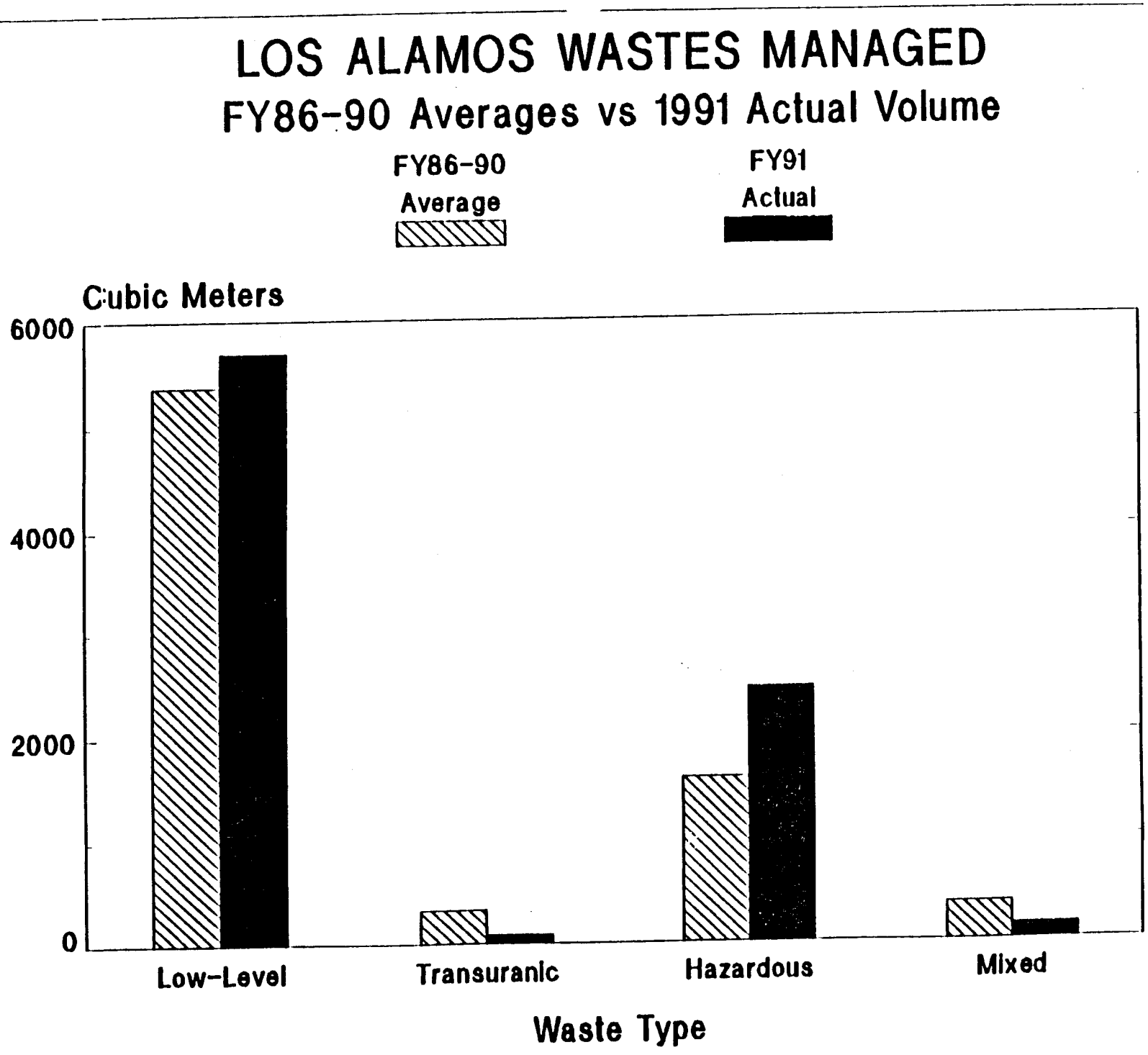

LOS ALAMOS WASTES MANAGED
FY86-90 Averages vs 1991 Actual Volume
FY86-90 Average
FY91 Actual
Cubic Meters
6000
4000
2000
0
Low-Level
Transuranic
Hazardous
Mixed
Waste Type

Figure 6

LOS ALAMOS WASTES MANAGED

Fiscal Years 1986 - 1991

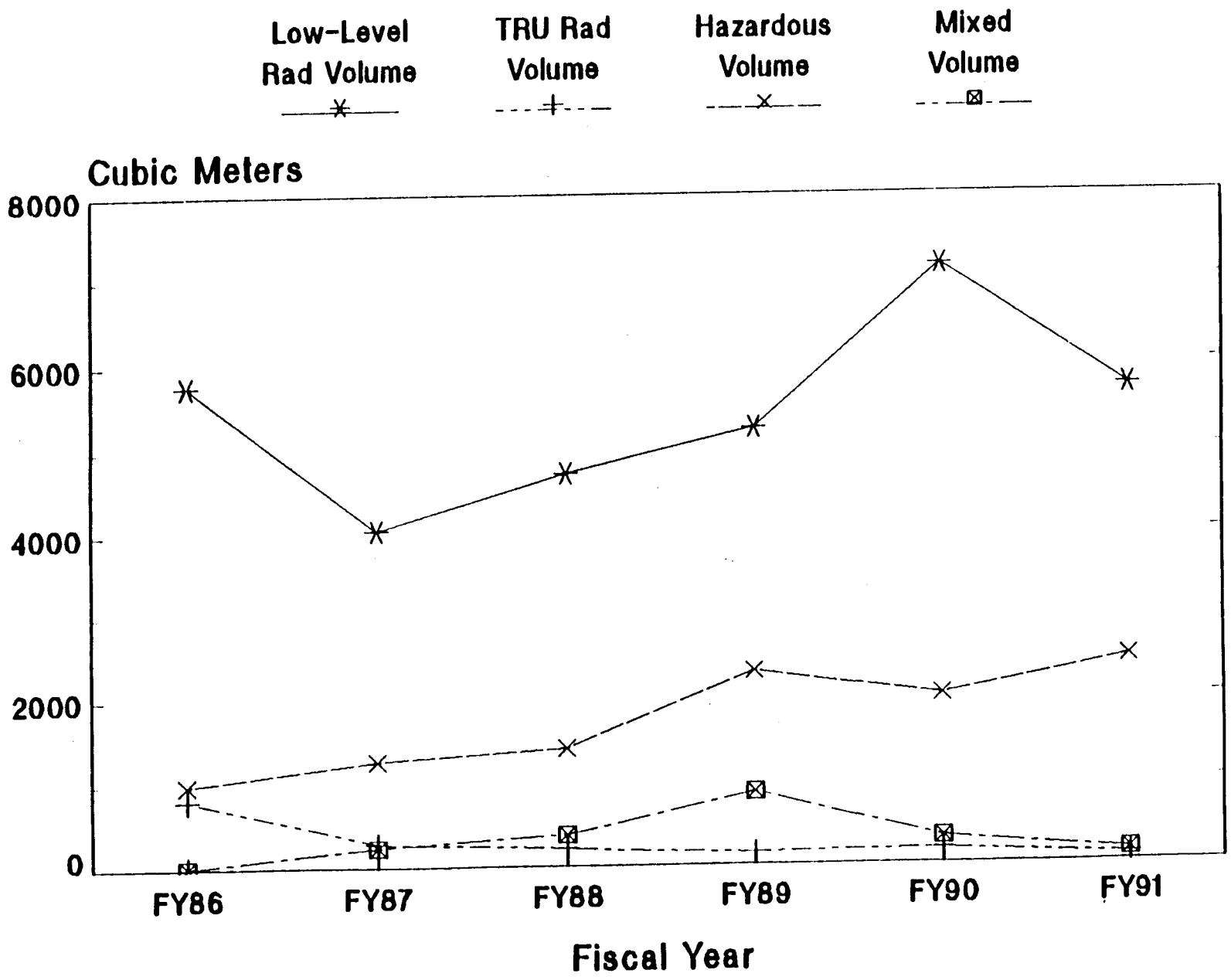


Figure 7

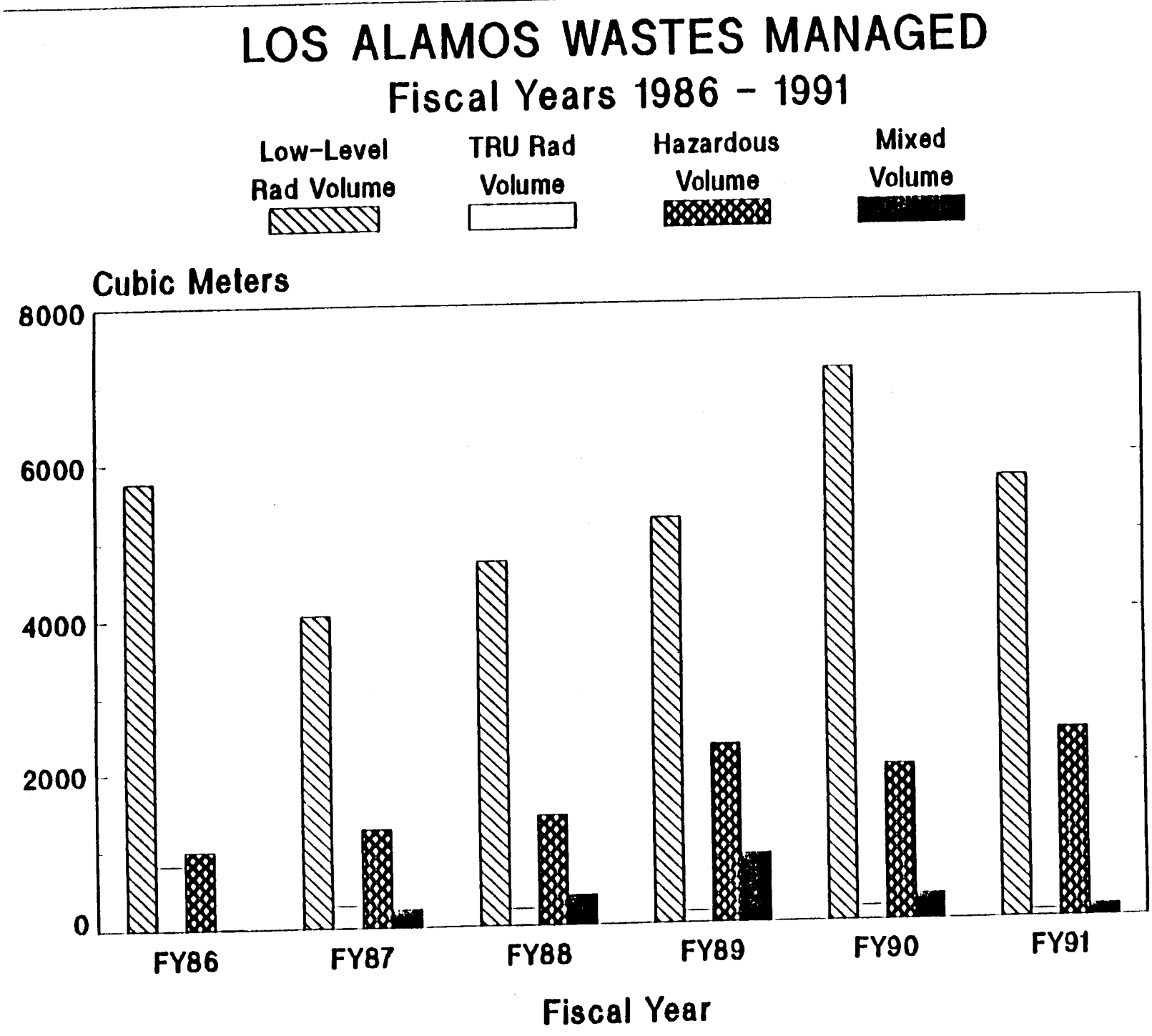

LOS ALAMOS WASTES MANAGED
Fiscal Years 1986 - 1991
Low-Level Rad Volume
TRU Rad Volume
Hazardous Volume
Mixed Volume
Cubic Meters
8000
6000
4000
2000
0
FY86
FY87
FY88
FY89
FY90
FY91
Fiscal Year

Figure 8

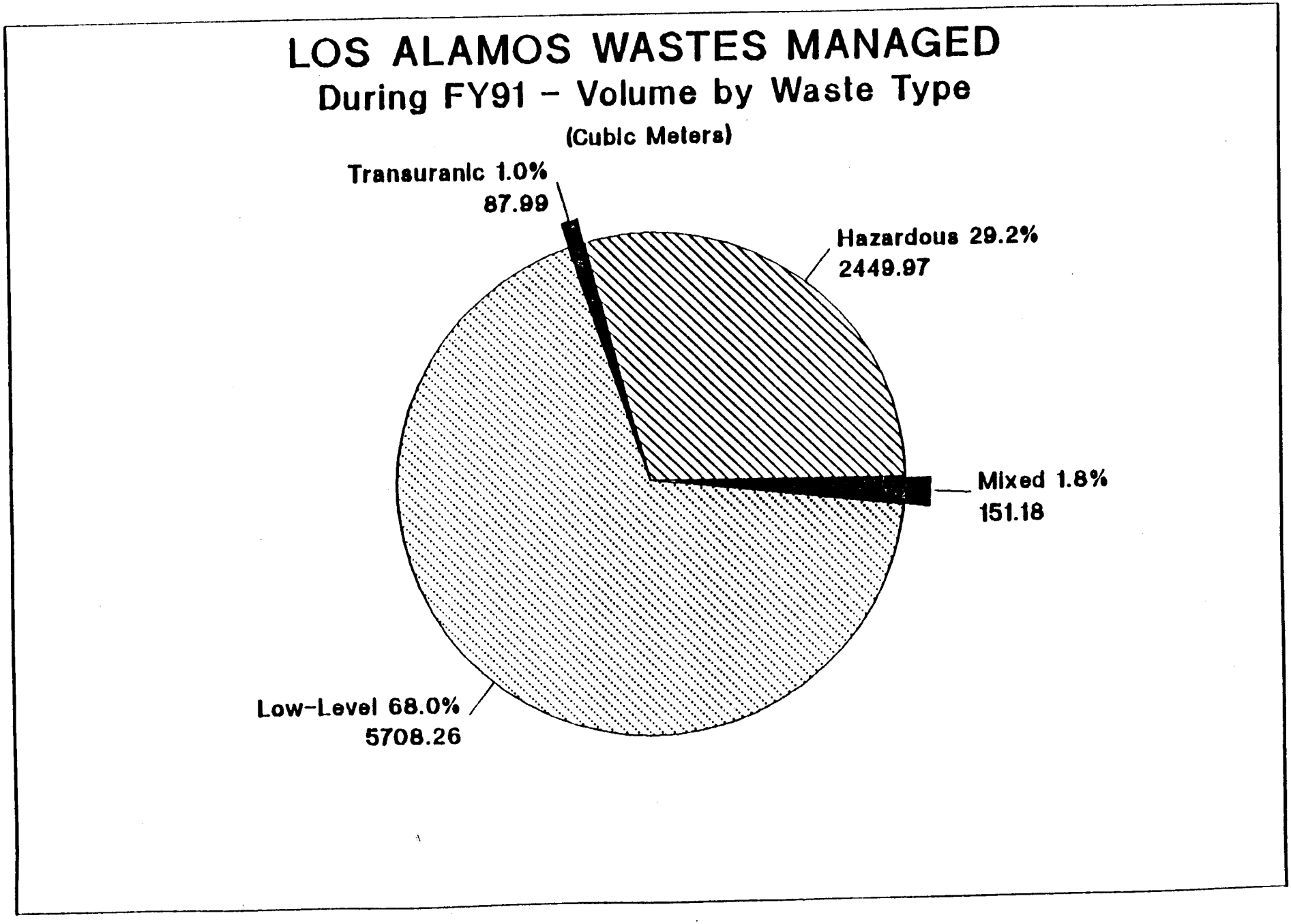

LOS ALAMOS WASTES MANAGED
During FY91 – Volume by Waste Type
(Cubic Meters)
Transuranic 1.0%
87.99
Hazardous 29.2%
2449.97
Mixed 1.8%
151.18
Low-Level 68.0%
5708.26

Figure 9

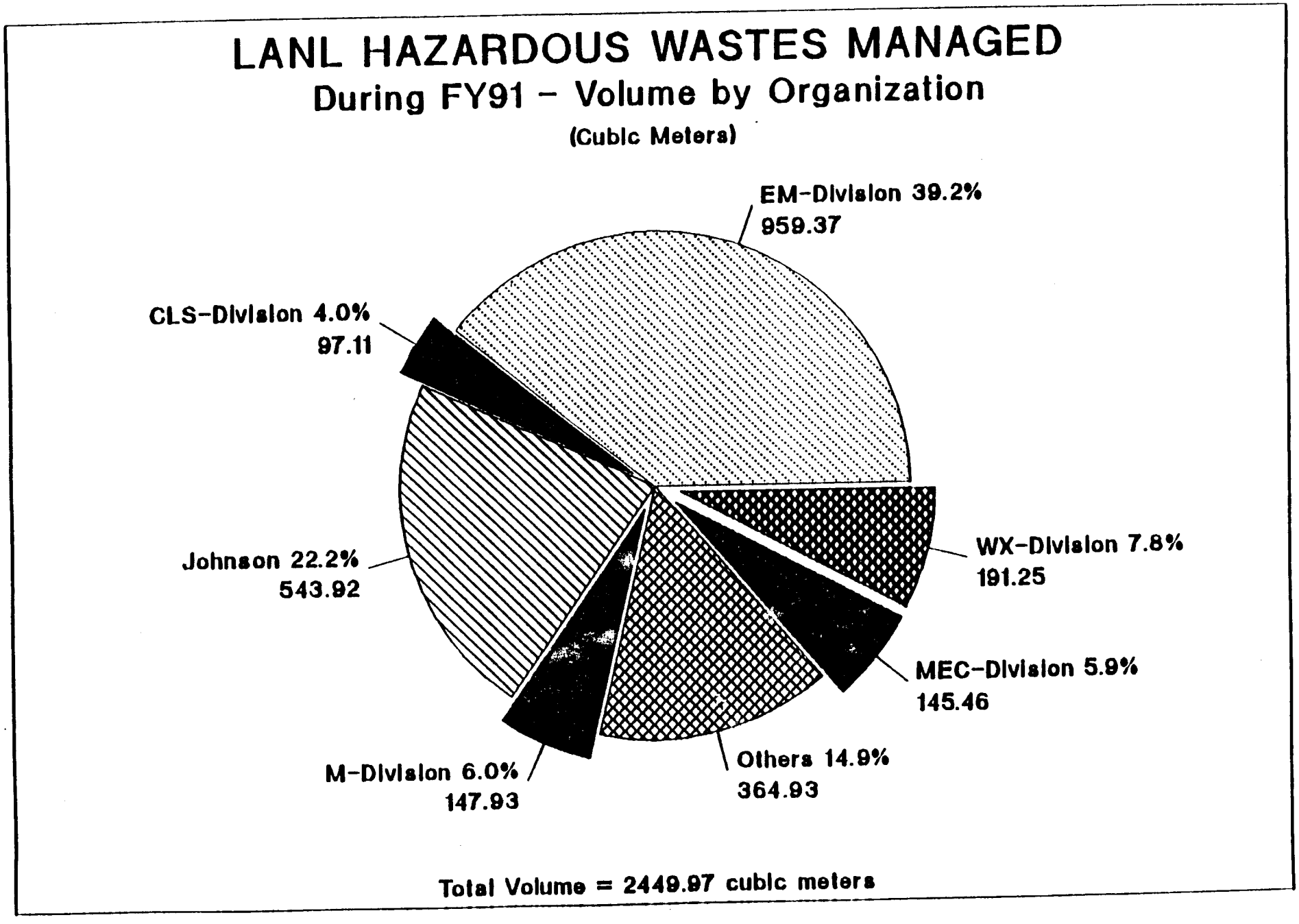
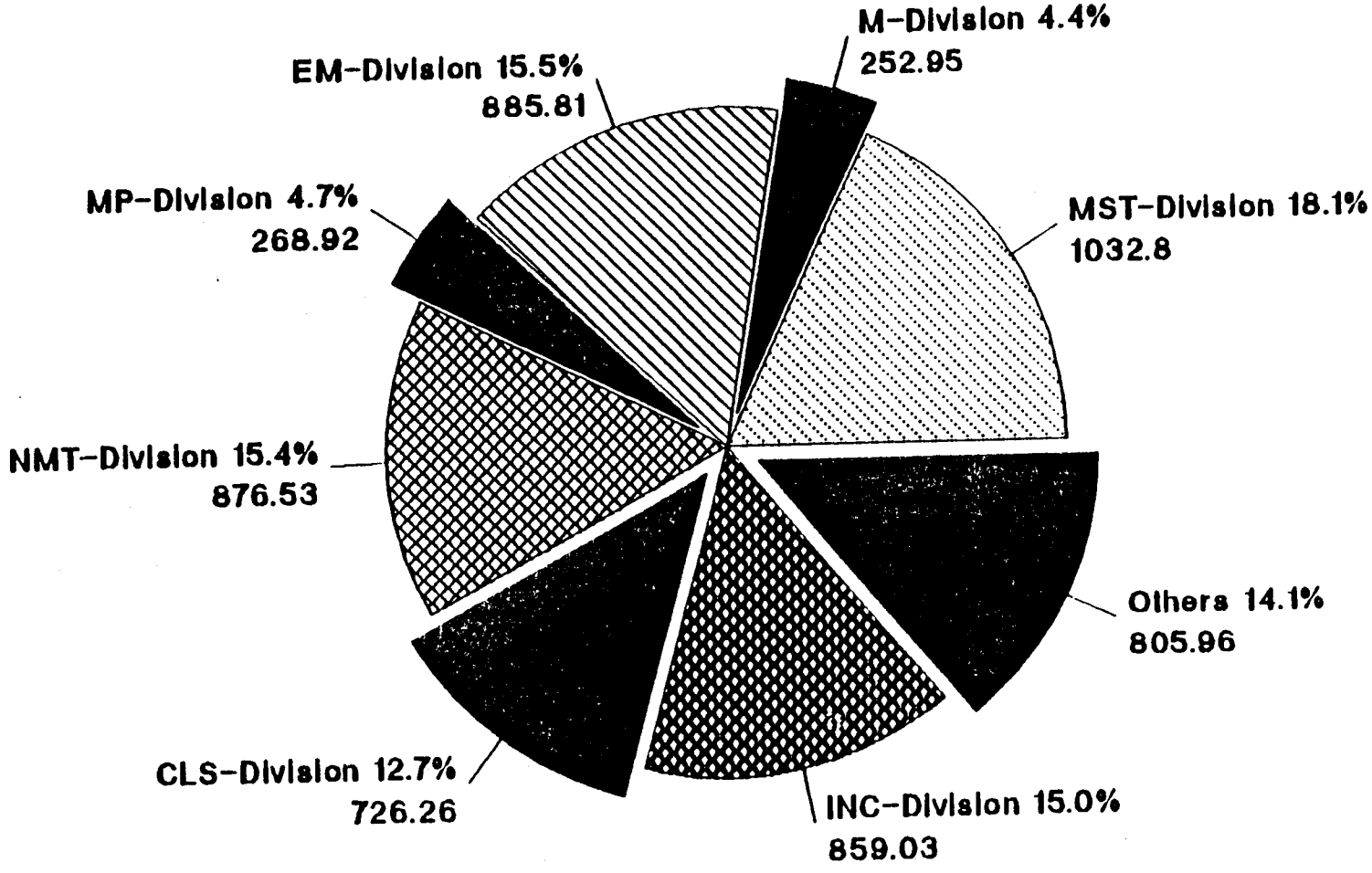

LANL HAZARDOUS WASTES MANAGED
During FY91 - Volume by Organization
(Cubic Meters)
EM-Division 39.2%
959.37
CLS-Division 4.0%
97.11
Johnson 22.2%
543.92
WX-Division 7.8%
191.25
MEC-Division 5.9%
145.46
M-Division 6.0%
147.93
Others 14.9%
364.93
Total Volume = 2449.97 cubic meters

Figure 10

LANL LOW-LEVEL WASTES MANAGED

During FY91 - Volume by Organization

(Cubic Meters)

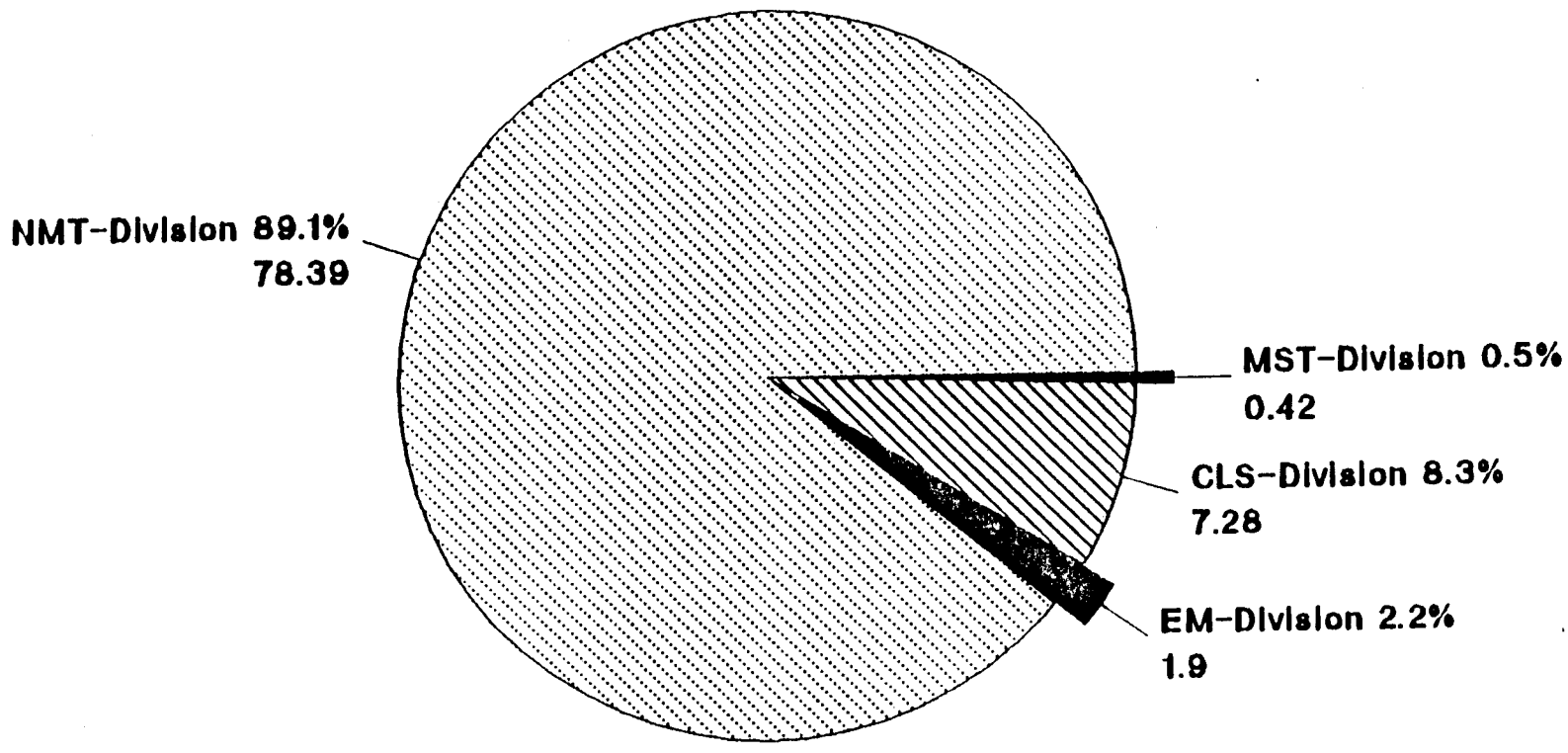


Total Volume = 5708.26 cubic meters

LANL TRANSURANIC WASTES MANAGED

During FY91 - Volume by Organization

(Cubic Meters)



Total Volume = 87.99 cubic meters

Figure 12

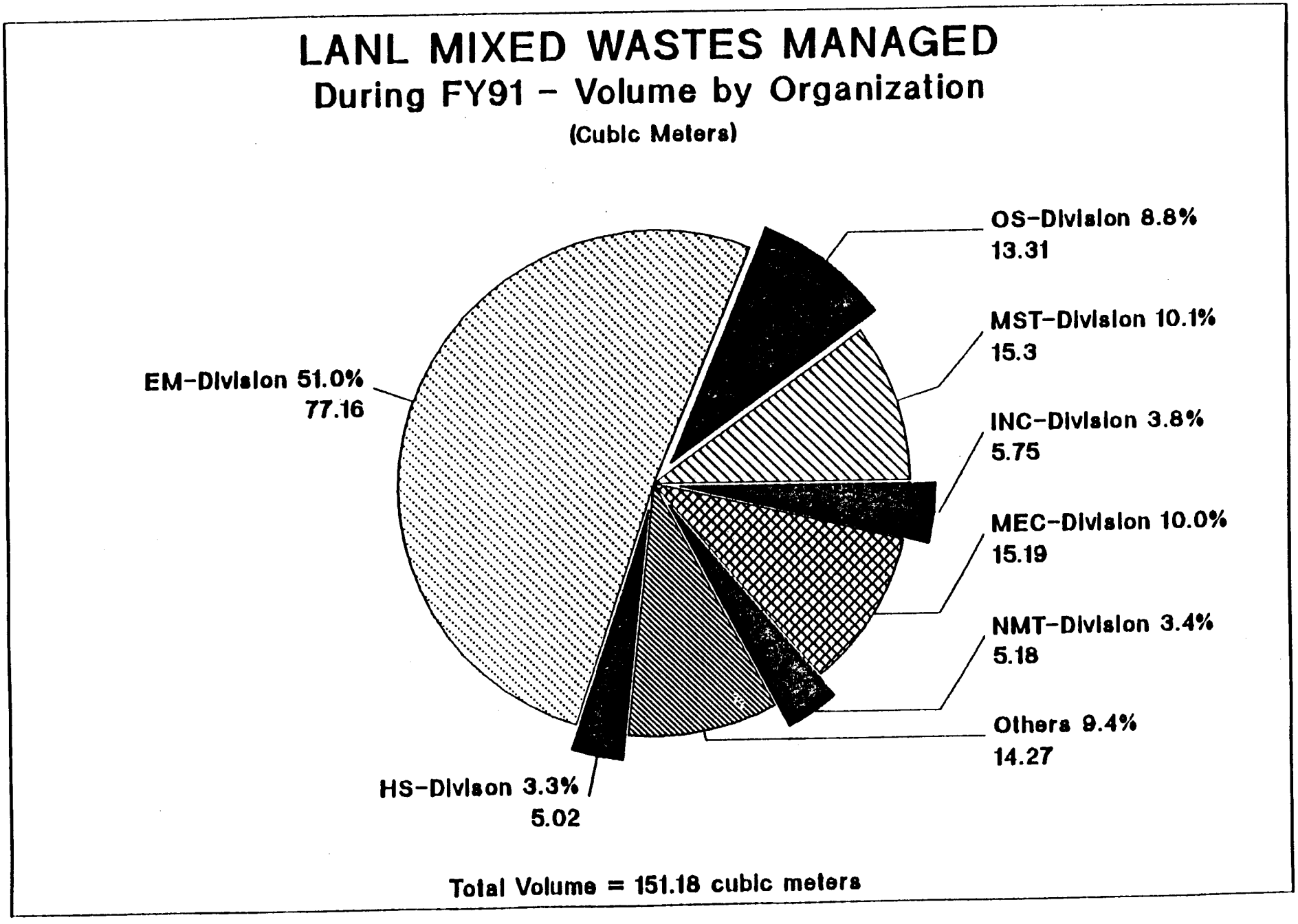

LANL MIXED WASTES MANAGED
During FY91 - Volume by Organization
(Cubic Meters)
OS-Division 8.8%
13.31
MST-Division 10.1%
15.3
INC-Division 3.8%
5.75
MEC-Division 10.0%
15.19
NMT-Division 3.4%
5.18
Others 9.4%
14.27
HS-Divison 3.3%
5.02
EM-Division 51.0%
77.16
Total Volume = 151.18 cubic meters

Figure 13

APPENDIX C

PROCESS WASTE ASSESSEMENT PLAN

PROCESS WASTE ASSESSMENT PLAN

Jeffrey B. Weinrach
Waste Minimization Program Office
Los Alamos National Laboratory

March 1992

OVERVIEW

In order to implement a cohesive waste minimization plan, it is important to have an initial assessment of the various waste streams at the facility. At a facility such as Los Alamos National Laboratory (LANL) where the waste streams typically are small but diverse, the best assessments would be done by the generators of the waste streams since they are, in most instances, the only people who have the process knowledge necessary to make a thorough assessment. Software developed at LANL will help waste generators make waste assessments and evaluate potential waste minimization technologies. Included in the assessments are a complete mass balance to ensure that the process is being modeled completely; a trackable history of selected wastes (graphically displayed); cost, energy, and manpower considerations such as hours worked or hazardous exposures. The system also provides the opportunity to evaluate potential waste minimization solutions (either through a Best Available Technologies database or through graphical input) and determine any downstream ramifications of implementing these solutions.

INTRODUCTION

The approach taken to perform process waste assessments at Los Alamos National Laboratory involves the development and implementation of a user-friendly software package designed to provide waste management coordinators and waste generators with tools and information to be used as resources for modeling processes and carrying out self-assessments. This approach has distinct advantages over the alternate approach of assembling a team with process-knowledge expertise who would have the major responsibility of

performing the process waste assessments. This is because the waste streams at a laboratory such as Los Alamos are quite diverse in terms of both volume and toxicity. Also, the nature of the work that goes on at Los Alamos dictates that the waste streams will change quite frequently and therefore will require numerous modifications and updates to any waste tracking or process tracking mechanism. The experience at Los Alamos with similar audit teams have shown that these teams do not provide suitable support to the waste generators. In order to provide the most practical program to the Laboratory while still performing the necessary function of process waste assessments, the development and utilization of user-friendly software for self-assessments will be carried out.

The software was originally developed under funding from DOE-Albuquerque initially to model the Rocky Flats Plant production processes. Since the initial effort, the model has been extended to DOE's Pantex facility to study material flows and processing. In both situations, the program was not designed to be used by waste generators and therefore was not user-friendly. The major modifications that are being made to make the program operational for Los Alamos are the development of the graphical interface and a database for storing important information. These aspects to the overall program will be discussed in more detail below.

The program defines locations, process steps, equipment, and the relationships between them. Mass balance is one of the requirements for the equipment definitions. This ensures that the complete waste stream (comprised of the defined equipment as well as locations and process steps) also maintains mass balance. The generation of the model waste stream with these features dramatically helps the waste management coordinator and the waste generator (who ultimately is responsible for waste minimization) to gain the knowledge-of-process needed to make the waste minimization decisions. Once the model has been generated, the program user can then modify the process with newly defined equipment and/or process steps and monitor the degree of waste minimization that would be attained if the new process were to be implemented. The program will also track other important variables such as cost, energy consumption, and radiation exposure which should also be included in waste minimization assessments since it is the overall efficiency of the process that needs to be addressed.

Since laboratory-type waste streams are often quite diverse in terms of volume as well as constituents, the level of detail needed to properly model these waste streams should be flexible as long as the integrity of the self-assessment program is maintained. The program being developed at Los Alamos allows the waste management coordinator or waste generator to control the level of detail and the manner in which the waste stream is modeled. This greatly helps waste generators make some of the initial decisions regarding waste minimization opportunities. For example, if a certain procedure for cleaning equipment is always being used, it probably would not be necessary to model every step in that cleaning process for all applications. Therefore, the entire cleaning operation (perhaps comprising many individual steps) could be modeled as one large process. The program also allows for the program user to change the level of detail from specific to general or vice versa as needs warrant. This feature would be helpful if environmental reports that require a certain degree of consistency (such as air emissions or liquid discharge) are requested of the waste management coordinators.

PROJECT STATUS

The project has been divided into eight major steps:

1) Development of code,

2) Testing of code at selected sites,

3) Evaluation of test results,

    a) Success of code,

    b) Comparison with other pertinent data,

4) Modification of code base on test results,

5) Training of waste management coordinators,

6) Maintaining program (consulting, etc.),

7) Compiling information from waste management coordinators,

8) Generating Laboratory-wide waste assessment reports.

Development of code

The software is primarily comprised of three components: the program, the interface, and the database. The program being used is written in common LISP language. A graphical interface package, INFOCAD, will be implemented to allow the program to be more user-friendly. Other interface packages will be developed as needed. Databases such as ORACLE will be used to compile data from the program and generate standard reports for waste minimization activity or other environmental reporting requirements. Prioritization algorithms are being developed to weight various waste minimization options if more than one scenario is being considered. The program runs on SUN workstations, McIntosh's, and PC's.

Testing of code at selected sites

Selected sites have been chosen at the Laboratory to test the program. These sites contain a variety of waste streams with many processes involved in the generation of hazardous, radioactive, and mixed wastes. Waste management coordinators at these sites are being trained on the purpose and scope of the waste assessments as well as the utilization of the program to perform the assessments and the eventual evaluations of waste minimization technologies. The test sites include electroplating and metal finishing facilities.

Evaluation of test results

The testing phase consists of several components: 1) success of the code in properly modeling laboratory-type waste streams, and 2) comparison with other pertinent data. The success of the code will be based on both the accuracy in modeling the various waste streams and the user-friendliness of the program by waste management coordinators and waste generators. Comparisons with other data will concentrate on waste tracking information that is currently maintained by the waste management facility at Los Alamos and chemical tracking information which will be primarily used for inventory control. These tracking systems only monitor either waste volumes or types or chemical storage information (as opposed to process flow

information) and therefore are not sufficient for waste assessments and evaluations for waste minimization.

Modification of code based on test results

Based on the testing data, modifications to the program and interface will be made. These modifications will include generation of ad hoc reports from graphical displays, improved connectivity between various equipment in a particular waste-generating process, and graphical tracking of particular components of a waste stream.

Training of waste management coordinators

During the testing and modification phases, waste management coordinators at the Laboratory will be notified as to the progress in program development. Once the testing and modification phases are complete, waste management coordinators will be trained as to the use of the program and the type of assessments that would result in waste minimization opportunity. Documentation of assessments and evaluations will also be discussed as well as future environmental reporting requirements that could be handled by the application of this program.

Maintaining program

The program and database will be maintained by Laboratory personnel both in terms of software and hardware maintenance and consultation with Laboratory waste management coordinators. A BAT (Best Available Technology) database will be developed to allow program users to access new waste minimization technology information and assess these new technologies as part of their waste-generating processes. The implementation of the BAT database might be delayed due to financial constraints. Ratings of these new technologies will be determined and evaluated for waste minimization potential. Factors such as cost and potential risk to human health or the environment will be weighted as part of the waste assessment process. Periodic reviews of the utilization of the program will be performed to ensure that the program is being used to its maximum efficiency.

Compiling information from waste management coordinators

At regular intervals (monthly, quarterly, etc.) data will be compiled by the Los Alamos National

Laboratory Waste Minimization Program Office. This data will include a graphical representation of the waste streams being modeled as well as evaluations of potential waste minimization solutions. Recommendations from the Waste Minimization Program Office will be made to waste management coordinators when appropriate. Comparisons will be made between various Laboratory waste stream models as well as between the data collected through these assessments and waste tracking data. Potential improvements in the use of the program as determined by evaluating the general success in waste assessments will be presented to waste management coordinators.

Generating Laboratory-wide waste assessment reports

Once the data have been compiled and evaluated, Laboratory-wide waste assessment reports will be available to internal and external readers. Periodic reports will be submitted to DOE for review.

PROJECT TEAM

The project team consists of members from six organizations:

1) Los Alamos National Laboratory Waste Minimization Program Office (EM-DO) - primary responsibility for managment and oversight of development and implementation of PWA program,

2) Energy and Environmental Analysis (A-4) - cost/risk analysis and prioritization of waste streams and waste minimization scenarios,

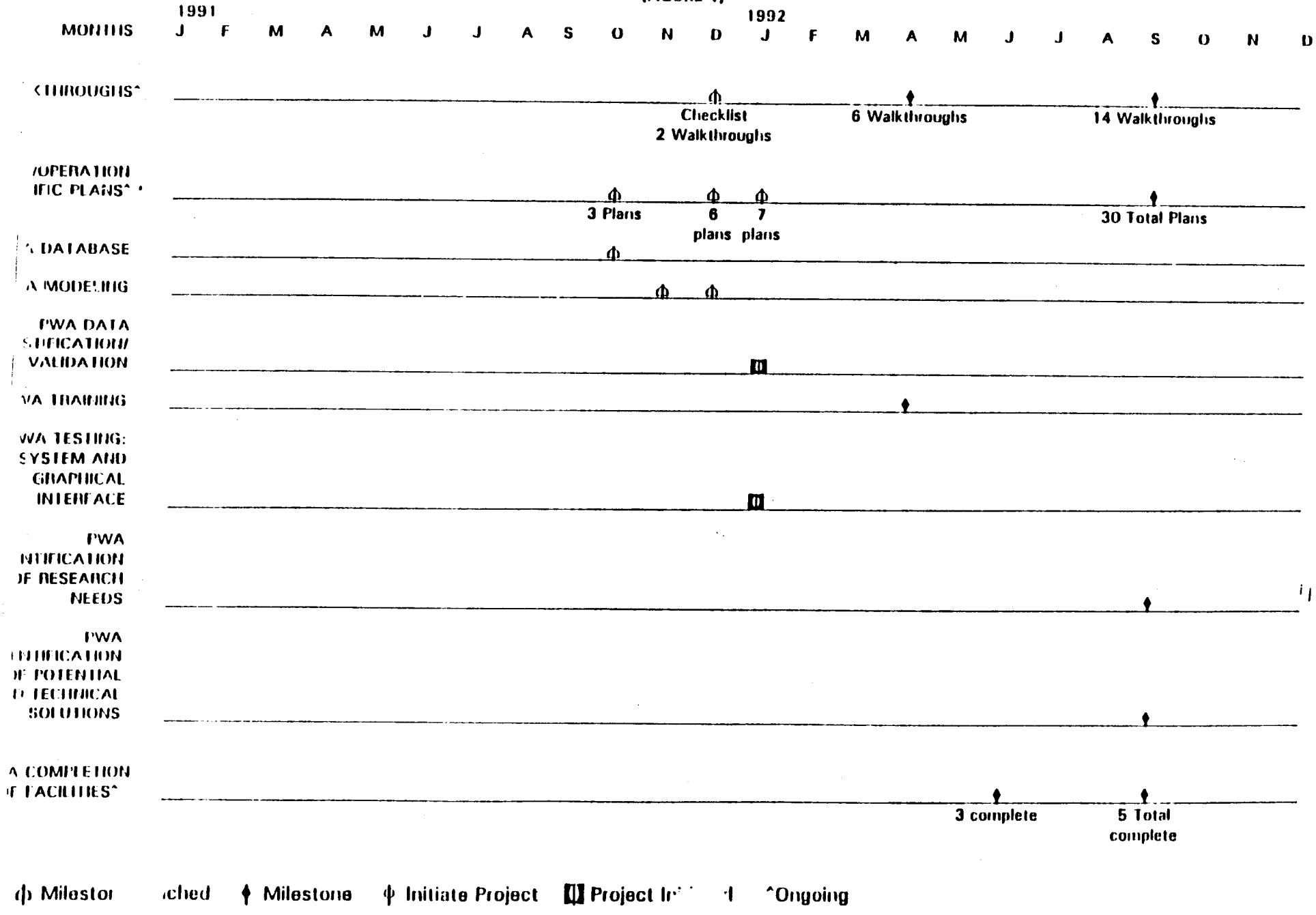
3) Technology Modeling and Analysis (A-7) - development of software and graphical interface,

4) Process Engineering (MEE-9) - technical support for assessments and evaluations of waste minimization technology,

5) Planning (ENG-2) - location information for waste-generating processes and outfalls,

6) Benchmark Environmental Corporation (sub-contractor for LANL) - development of database requirements and Best Available Technologies (BAT) database. Implementation of BAT database could be delayed due to financial constraints.

PROCESS WASTE ASSESSMENT MILESTONES
1991 - 1992
(FIGURE 1)



PROJECT MILESTONES AND GOALS

Project Milestones and goals are represented in Figure 1. These goals are subject to change depending upon financial constraints.

CONCLUSION

The approach being taken at Los Alamos National Laboratory to comply with the Department of Energy regarding Process Waste Assessments involves the use of a user-friendly program and database that will allow waste management coordinators and waste generators to perform self-assessments of their particular waste streams. This program will help waste generators acquire knowledge-of-process which is becoming increasingly important in environmental awareness programs. The database will allow a greater degree of flexibility both in terms of level of detail needed for a successful model and also in terms of modifying the model to account for major changes in waste streams that typically occur at the Laboratory. It will also be used to evaluate potential waste minimization opportunities before major investments would usually be made. This program can also be used to comply with new environmental reporting requirements dealing with various aspects of waste characterization. Overall, this user-friendly approach to waste assessments should provide more benefit than other standard approaches for individuals who have the task of modifying their processes in order to address waste minimization concerns.

APPENDIX D

DIRECTOR'S POLICY

LOS ALAMOS NATIONAL LABORATORY

DIRECTOR'S POLICY

DP No. 105

September 1991

SUBJECT: Hazardous and Radioactive Waste Management

1.0 PURPOSE

This policy defines the basic requirements for management to be aware of, oversee, and control the gaseous, liquid, and solid wastes at the Laboratory so as to minimize the release of radioactive, hazardous and/or mixed wastes to the environment. This policy is in accordance with Department of Energy requirements to comply with applicable federal, state, local laws and regulations, DOE orders, memoranda of understanding, other agreements, and consent decrees relating to hazardous and radioactive waste management.

Discussion. This policy addresses issues of waste management. It does not address mitigating measures required for distributing, handling, and controlling radioactive and hazardous materials in the workplace. Nor does this policy establish the procedural controls necessary to manage radioactive and hazardous materials in compliance with appropriate regulatory rules and regulations. Employee, subcontractor, and public health protection concerns associated with radioactive and hazardous materials are covered in other Director's Policies.

2.0 POLICY

Operations involving Laboratory-generated radioactive, hazardous and/or mixed wastes shall be performed so as to

- protect the public, employees, and the environment;
- minimize generation of radioactive, hazardous and/or mixed wastes;
- comply with applicable federal, state, and local regulations for environmental protection and waste disposal; and
- continually search for effective means to improve Laboratory performance.

The Laboratory shall have programs for

- minimizing radioactive, hazardous, and/or mixed wastes including annual goals for improvement and incentives for exemplary performance;
- training personnel involved in operations that generate radioactive, hazardous and/or mixed wastes;
- collecting liquid and solid hazardous wastes and managing them in a manner which reduces toxicity and prevents the contamination of the environment;
- collecting solid and liquid radioactive wastes, applying volume-reduction techniques, and burying or storing in controlled facilities or using other compliant disposal methods;
- collecting, managing, controlling, handling, and disposing of mixed wastes;
- monitoring waste (gaseous, liquid, or solid) for the amount generated, stored, released, and disposed;
- generating and controlling complete records to document hazardous, radioactive, and mixed wastes from generation to disposal;
- providing decontamination services that promote recycling;

- providing decommissioning services for safe, efficient physical removal of facilities or equipment that have outlived their usefulness; and
- conducting applied development and application studies to more effectively manage, treat, and reduce the volume of solid and liquid radioactive, hazardous and/or mixed wastes so that storage and disposal operations are minimized.

3.0 RESPONSIBILITIES

The Director and the ES&H Council shall annually review goals for the hazardous and radioactive waste management programs and assess performance.

The Office of Primary Responsibility (OPR) shall be the Environmental Management Division (EM). The EM Division shall

- work with the Applied Environmental Technology Program Director to develop and provide the overall direction for the programs indicated above;
- collect, manage, handle, and dispose of all radioactive, hazardous, and mixed waste following receipt from the generators;
- monitor, evaluate, and report all waste streams including amounts generated;
- assist in the investigation and reporting of all compliance violations including determination of root causes;
- develop training to support this policy and the referenced programs;
- advise and assist Laboratory organizations in implementation of all programs and procedures derived under this policy; and
- work with the Applied Environmental Technology Program Director to develop goals and performance indicators for the hazardous and radioactive waste management programs.

Laboratory managers shall

- implement this policy, associated programs, and procedures and
- involve the EM Division prior to new or modified activities generating hazardous wastes.

Employees who work with hazardous and radioactive materials shall be trained and shall adhere to this policy in work activities.

The Laboratory Assessment Office shall conduct assessments of all Laboratory organizations to evaluate performance under this policy.

Director 9/16/91
Date

ROUGH DRAFT

1.0 PURPOSE

This policy defines the basic requirements for management to be aware of, oversee, and control the gaseous, liquid, and solid wastes at the Laboratory so as to minimize the release of radioactive, hazardous and/or mixed wastes to the environment. This policy is in accordance with Department of Energy requirements to comply with applicable federal, state, local laws and regulations, DOE orders, memoranda of understanding, other agreements, and consent decrees relating to hazardous and radioactive waste management.

Discussion. This policy addresses issues of waste management and minimization. It does not address mitigating measures required for distributing, handling, and controlling radioactive and hazardous materials in the workplace. Nor does this policy establish the procedural controls necessary to manage radioactive and hazardous materials in compliance with appropriate regulatory rules and regulations. Employee, subcontractor, and public health protection concerns associated with radioactive and hazardous materials are covered in other Director's Policies.

2.0 POLICY

Operations involving Laboratory-generated radioactive, hazardous and/or mixed wastes shall be performed so as to

- protect the public, employees, and the environment;
- minimize generation of radioactive, hazardous and/or mixed wastes;
- comply with applicable federal, state, and local regulations for environmental protection and waste disposal;
- prevent generation of waste wherever and whenever possible;
- recycle waste that cannot be eliminated at the source wherever technically and economically feasible;
- give prime consideration to reducing or eliminating waste in all Laboratory programs; and
- continually search for effective means to improve Laboratory performance.

The Laboratory shall have programs for

- ~~minimizing radioactive, hazardous, and/or mixed wastes including annual goals for improvement and incentives for exemplary performance;~~
- minimizing waste by systematically eliminating or reducing generation of waste from site operations through periodic Process Waste Minimization Assessments, setting minimization goals, implementation of Site Specific Waste Minimization Plans, employee awareness and training, tracking and reporting of waste generation rates, and program effectiveness evaluation;
- making source reduction and environmentally sound recycling integral parts of the philosophy and operation of the Laboratory;
- training personnel involved in operations that generate radioactive, hazardous and/or mixed wastes;
- collecting liquid and solid hazardous wastes and managing them in a manner which reduces toxicity and prevents the contamination of the environment;
- collecting solid and liquid radioactive wastes, applying volume-reduction techniques, and burying or storing in controlled facilities or using other compliant disposal methods;
- collecting, managing, controlling, handling, and disposing of mixed wastes;
- monitoring waste (gaseous, liquid, or solid) for the amount generated, stored, released, and disposed;

- generating and controlling complete records to document hazardous, radioactive, and mixed wastes from generation to disposal;
- providing decontamination services that promote recycling;
- providing decommissioning services for safe, efficient physical removal of facilities or equipment that have outlived their usefulness; and
- conducting applied development and application studies to more effectively manage, treat, and reduce the volume of solid and liquid radioactive, hazardous and/or mixed wastes so that storage and disposal operations are minimized.

3.0 RESPONSIBILITIES

The Director and the ES&H Council shall annually review goals for the hazardous and radioactive waste management and minimization programs and assess performance.

The Office of Primary Responsibility (OPR) shall be the Environmental Management Division (EM). The EM Division shall

- work with the Applied Environmental Technology Program Director to develop and provide the overall direction for the programs indicated above;
- collect, manage, handle, and dispose of all radioactive, hazardous, and mixed waste following receipt from the generators;
- monitor, evaluate, and report all waste streams including amounts generated;
- assist in the investigation and reporting of all compliance violations including determination of root causes;
- develop training to support this policy and the referenced programs;
- advise and assist Laboratory organizations in implementation of all programs and procedures derived under this policy; and
- work with the Applied Environmental Technology Program Director to develop goals and performance indicators for the hazardous and radioactive waste management programs.

The Waste Minimization Program Office within EM-DO shall

- chair a management level committee made up of representatives of generating functions;
- provide oversight and guidance for implementation of waste minimization efforts;
- help generators to identify potential technical and administrative solutions for waste generating problems and assist in preparation of Site Specific Plans;
- set waste minimization goals and track and report waste minimization data
- provide data for inclusion in required federal and state reports.

Laboratory managers shall

- implement this policy, associated programs, and procedures,
- involve the EM Division prior to new or modified activities generating hazardous wastes,
- be responsible for funding and implementing their Site Specific Waste Minimizatin Plan,
- identify technical and administrative solutions for waste generating problems,
- provide a waste coordinator for waste minimization activities in that activity, and

ROUGH DRAFT

The Waste Minimization Committee shall secure and coordinate management support for oversight, guidance, and implementation of waste minimization.

Employees who work with hazardous and radioactive materials shall be trained and shall adhere to this policy in work activities.

The Laboratory Assessment Office shall conduct assessments of all Laboratory organizations to evaluate performance under this policy.

ROUGH DRAFT

Director Date

■ APPENDIX C

Maps of Wetlands, Drainages, and Well Locations

1.0 INTRODUCTION

The maps located at the end of this appendix are representative of the maps that are available at Los Alamos National Laboratory (the Laboratory). These maps have been scaled to fit a normal page format for ease of reproduction with the rest of this document. The Geographical Information System—which is part of the Facility for Information Management, Analysis, and Display—contains topographical information in digital form derived from recent aerial photography. Topographic maps with high resolution can be generated from this system by computer. If maps are needed with higher resolution of particular features than are provided in this appendix, requests should be submitted to the Environmental Restoration Program's community reading room, Los Alamos National Laboratory, PO Box 1663, MS M314, Los Alamos, New Mexico 87545.

2.0 WETLANDS

Four federal agencies have responsibility for identifying and delineating wetlands: the Army Corps of Engineers, Environmental Protection Agency (EPA), Fish and Wildlife Service (FWS), and Soil Conservation Service (SCS). The Corps and EPA are responsible for wetlands regulated under Section 404 of the Clean Water Act. Under Section 404, the Secretary of the Army, acting through the Chief of Engineers, is authorized to issue permits for the discharge of dredged or fill materials into the waters of the United States, including wetlands. The FWS has been involved in a nationwide identification of wetlands through the National Wetlands Inventory (NWI). The SCS becomes involved in identifying wetlands through the "swampbusters" provision of the Food Security Act of 1985 (Army Corps of Engineers et al. 1989, 0237).

The FWS has undertaken a project to map and characterize those wetlands in accordance with the NWI. This inventory includes all wetlands and deepwater habitats throughout the United States, including rivers, lakes, streams, marshes, bogs, and ponds.

The NWI meets four long-range objectives set forth by the FWS: (1) to describe ecological units that have similar natural attributes, (2) to arrange these units in a system that will aid decisions about resource management, (3) to delineate units for inventory and mapping, and (4) to provide uniformity in concepts and terminology throughout the United States (Illinois Department of Conservation 1988, 0322).

Under Section 404 of the Clean Water Act, a wetland is defined as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Wetlands include swamps, marshes, bogs, and similar areas. This definition emphasizes hydrology, vegetation, and saturated soils. In addition, Section 404 regulates other "waters of the United States" such as open water areas, mud flats, coral reefs, riffle and pool complexes, vegetated shallows, and other aquatic habitats.

The FWS in cooperation with other federal and state agencies, private organizations, and individuals, developed a wetlands definition for conducting an inventory of the nation's wetlands. This definition was published by Cowardin et al. (1979, 0248). In the NWI, wetlands are defined as "lands transitional between aquatic and terrestrial systems where the water table is usually at or near the surface, or the land

is covered by shallow water." In addition, the definition in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands requires that the land support predominantly hydrophytes and that the substrate be undrained hydric soils.

Under the Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendments (HWSA) Module of the Laboratory's operating permit, the EPA required a determination of all wetlands located in areas that either lie within Laboratory boundaries or that drain Laboratory land (Figure C-1).

2.1 National Wetlands Inventory Maps

The FWS designed the NWI maps only to provide guidance and did not intend to define the limits of proprietary jurisdiction or to establish geographic scope. The maps are prepared primarily by stereoscopic analysis of high-altitude aerial photographs. The FWS identified wetlands from the vegetation, visible water features, and geography observed in these photographs.

The NWI mapping protocol is hierarchical and is structured around a combination of ecological, hydrological, and substrate characteristics. This approach is consistent throughout the United States. The system consists of five components: marine (open ocean and associated coastline); estuarine (salt marshes and ponds); lacustrine (lakes and deep ponds); riverine (rivers, creeks, streams); and palustrine (shallow ponds, marshes, swamps, bogs). The system proceeds in a hierarchical manner through subsystem, class, and subclass and includes modifiers that describe the degree of wetness (water regime), water chemistry, soil, and manmade changes (diking, draining, etc.).

The wetlands at Los Alamos were mapped by FWS personnel from the Region 2 office in Albuquerque, New Mexico, using US Geological Survey quadrangle maps as base maps and infrared high-altitude aerial maps. To cover all of the watersheds that drain the Laboratory site, five quadrangles were mapped (Frijoles, White Rock, Guaje, Valle Toledo, and Puye). In addition to the watershed of the Laboratory proper, the Seven Springs quadrangle, which gives the location of the Laboratory's geothermal site at Fenton Hill, was mapped.

2.2 Results

The NWI maps all wetlands without emphasizing any particular type or location and is not restricted to mapping wetlands regulated by federal, state, or local regulatory agencies. The aerial maps typically reflect conditions during the specific year and season in which they were taken. A detailed on-the-ground and historical analysis of single sites is being conducted by personnel in the Environmental Protection Group (EM-8) to delineate and characterize individual wetlands.

No perennial streams traverse Laboratory lands. Wetlands within Laboratory boundaries fall primarily into two classifications: palustrine and riverine. Palustrine wetlands (ponds and marshes) have been identified in Sandia, Pajarito, and Pueblo canyons and small ones in other parts of the Laboratory. Wetlands in Sandia and Pueblo canyons are primarily maintained by effluent releases. Beds of ephemeral and intermittent streams that traverse the Laboratory have been classified as temporarily flooded riverine wetlands.

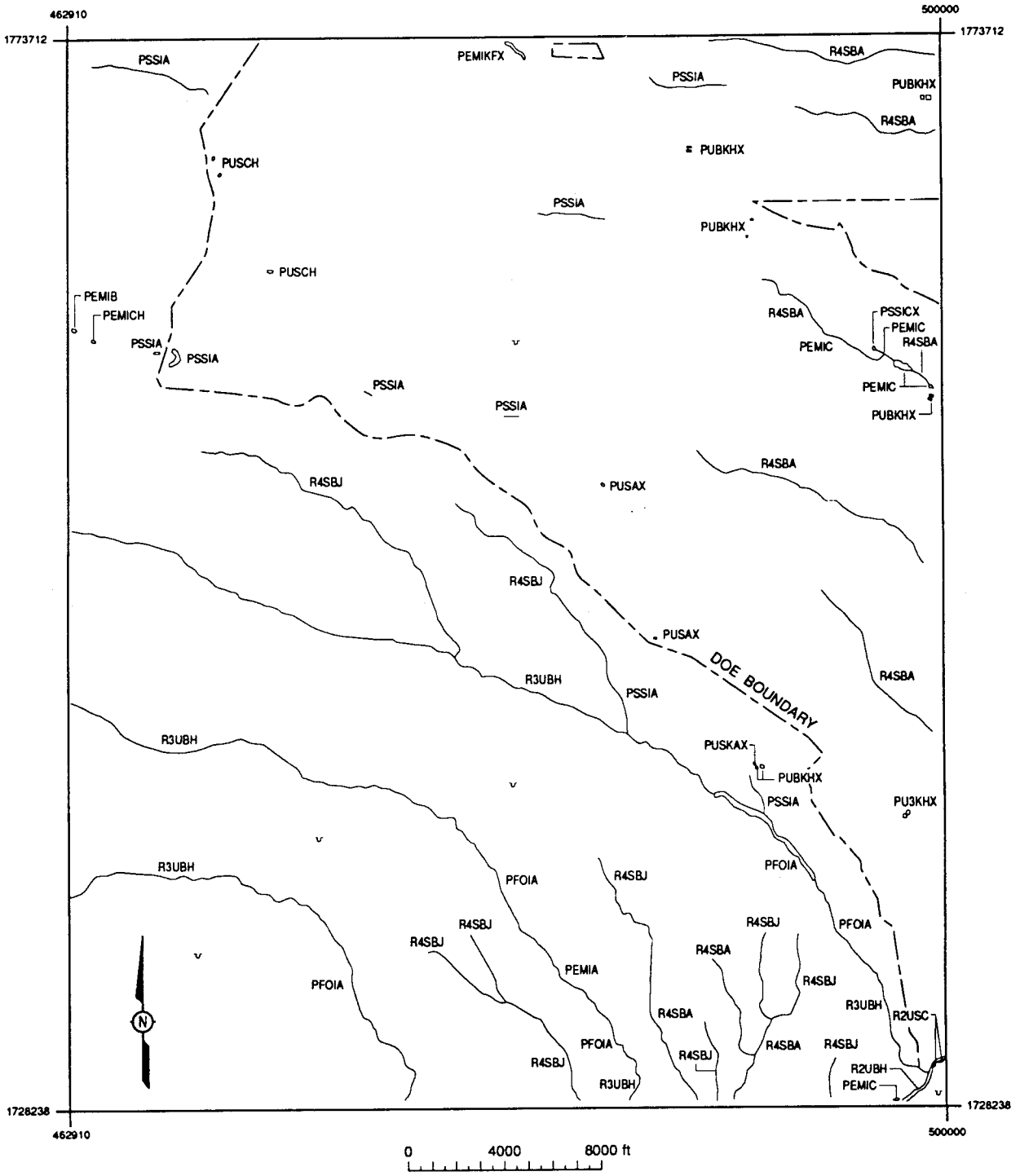


Figure C-1. Map of wetlands for Los Alamos County (p. 1 of 2).

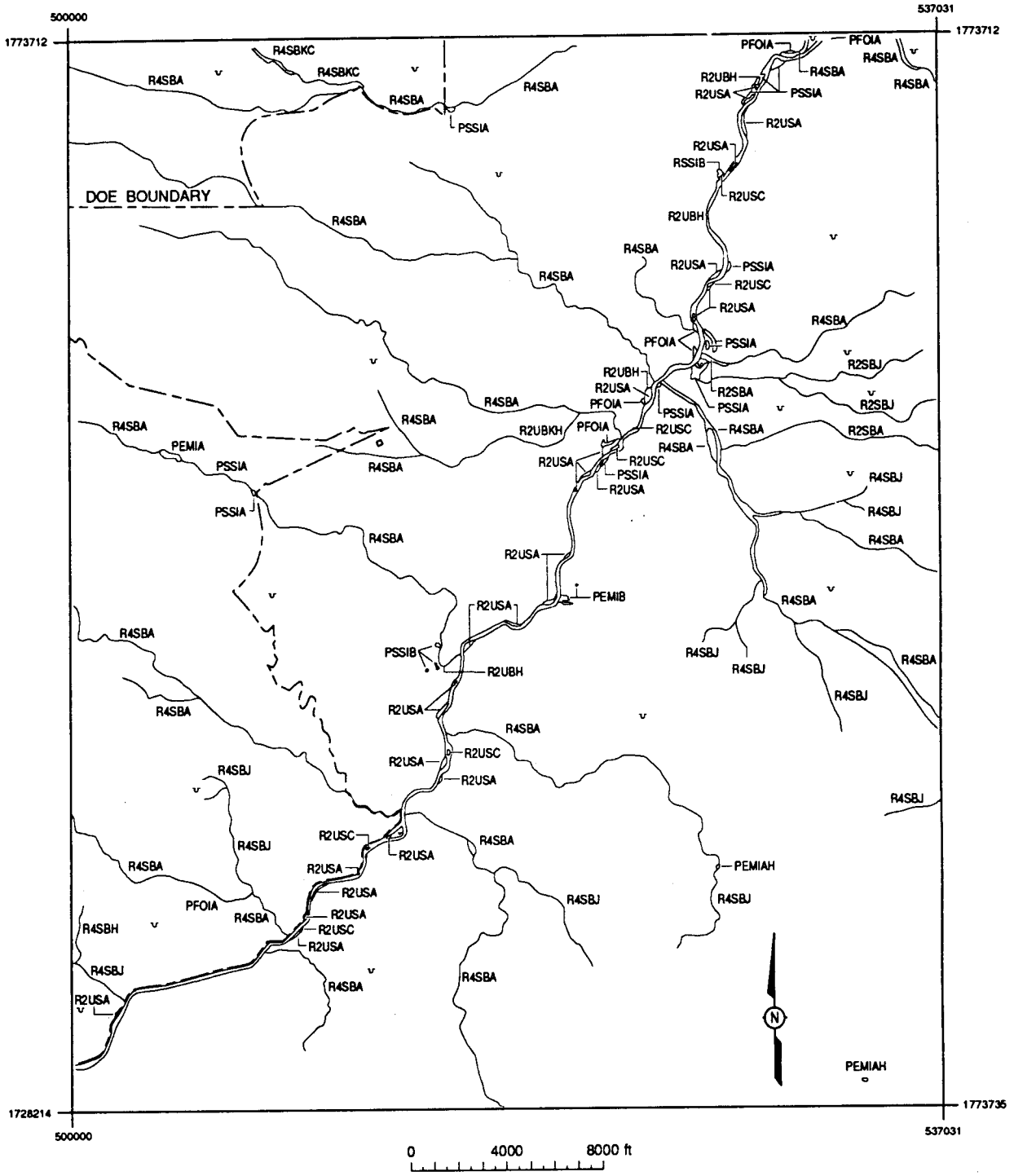


Figure C-1. Map of wetlands for Los Alamos County (p. 2 of 2).

2.3 Future Studies

Because the NWI maps are broad in scope and are not restricted to wetlands regulated by federal, state, or local regulatory agencies, a more detailed delineation of each wetland has been undertaken to determine jurisdictional status. During the summer of 1990, palustrine wetlands in Pajarito and Sandia canyons were characterized and delineated. In addition, use of the wetlands by various plant and animal species is being monitored. Because of the importance of these palustrine wetlands to diversity in plant and animal life, they will be monitored for more than a year to provide baseline data that will permit a determination of changes related to Laboratory activities.

In addition to monitoring the palustrine wetlands, riverine wetlands throughout the Laboratory will be characterized and delineated within the next 3 years as part of the RCRA facility investigation work plans. Most wetland mapping will be associated with the operable unit for the canyons system (OU 1049). The first step in characterization is to make an inspection of each canyon system from the headwaters to the Rio Grande, mapping small wetlands and delineating the boundaries.

3.0 WELL LOCATIONS

Figure C-2 shows the locations of wells in Los Alamos County and in adjacent locales.

Water Sampling Locations at Los Alamos

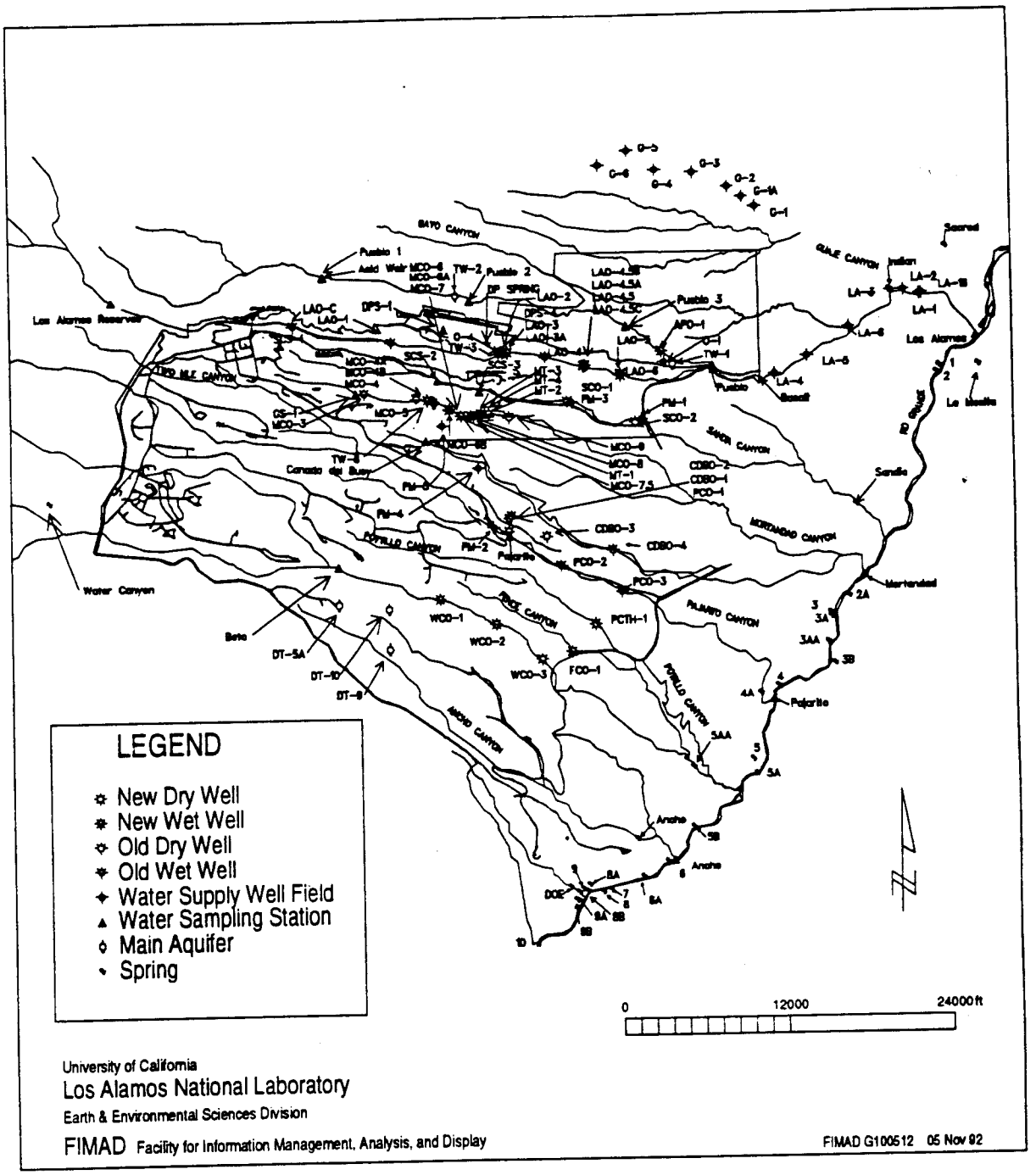


Figure C-2. Well locations in Los Alamos County and in adjacent locales.

References for Appendix C

Army Corps of Engineers, US Environmental Protection Agency, US Fish and Wildlife Service, US Soil Conservation Service, January 1989. "Federal Manual for Identifying and Delineating Jurisdictional Wetlands," Washington, DC. (Army Corps of Engineers et al. 1989, 0237)

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe 1979. "Classification of Wetlands and Deepwater Habitats of the United States," Office of Biological Services, Fish and Wildlife Service, US Department of Interior, Washington, DC. (Cowardin et al. 1979, 0248)

Illinois Department of Conservation 1988. "A Field Guide to Wetlands of Illinois," Springfield, Illinois. (Illinois Department of Conservation 1988, 0322)

■ APPENDIX D

Cover and Stabilization Pilot Studies

1.0 INTRODUCTION

Field and laboratory research funded by the US Department of Energy (DOE) at Los Alamos National Laboratory (the Laboratory) over the last 8 years has provided a basic understanding of the many environmental factors that influence the performance of landfills in response to hydrologic influences. That research has led to the development of landfill cover technology for controlling the precipitation that falls on a landfill. This cover technology is based on the combined results of studies on soil erosion (Nyhan et al. 1984, 0167;1986, 0169; Nyhan and Lane 1986, 0159), subsidence (Abeele 1984, 0002; 1984, 0003; 1984, 0004), biointrusion barriers (Hakonson et al. 1982, 0124; 1982, 0122; 1983, 0125; 1986, 0115; Felthauser and McInroy 1983, 0098), and capillary and hydraulic barriers (Abeele and DePoorter 1984, 0007; Nyhan et al. 1986, 0169).

This plan describes pilot demonstrations of landfill cover technology in the field at the Laboratory. Environmental Restoration (ER) Program funding of this study was initiated in 1990. Several cover designs are evaluated, including a conventional landfill cover, which is compared with a multilayered design recommended by the Environmental Protection Agency (EPA) and with two other landfill cover designs. The demonstrations will be constructed and instrumented so that complete water budgets can be estimated at field locations adjacent to Material Disposal Areas (MDAs) G and F. The results will be compared to determine which design best controls percolation and erosion and maximizes maintenance-free performance. Field tests aimed at studying long-term performance of shallow land burial systems will be completed at the Experimental Engineered Test Facility (EETF) at TA-51, at MDA B, and within transects of the piñon/juniper and ponderosa pine woodlands.

2.0 OBJECTIVES AND MILESTONES

Several approaches will be used to address the long-term stability and performance of protective barriers, as described in the project milestone chart (Figure D-1). Since 1982, the landfill cover designs at MDA B and at the integrated test plot (ITP) demonstration have been monitored continuously to produce a long, continuous data base. This data base was initiated in 1984 using data obtained from the ITP plots and was expanded in 1987 with data obtained from MDA B. Because it will probably not be possible to observe how the landfill cover components perform in a 100-yr precipitation event, a separate study will be performed in FY93 to address the hydrologic aspects of cover performance (capillary/hydraulic barriers) using artificially augmented precipitation. Beginning in 1993, the plots used in this study will be used to determine long-term interactions between capillary and hydraulic barriers and plant cover. Long-term relationships will also be studied in the natural piñon/juniper transect (adjacent to the ITP demonstration plots) and in other naturally vegetated areas whose vegetation is similar to the plant cover existing at MDA G (FY90 through the estimated 8-year life of the study). Transects were established and instrumented in the ponderosa pine woodland adjacent to MDA F in FY92 and will be monitored throughout the life of the study. One of the primary functions of these pilot studies will be to incorporate the results of the satellite (natural area) studies in the pilot program in a regional model to evaluate site integrity over the long term. By using the most advanced technology available, the investigators will ensure the comparability of all techniques used to measure hydrologic components, to characterize the surface, and to describe surface processes. The studies will (1) initiate a conceptual model for succession of woodland vegetation at remediated

MILESTONE CHART FOR PILOT STUDIES

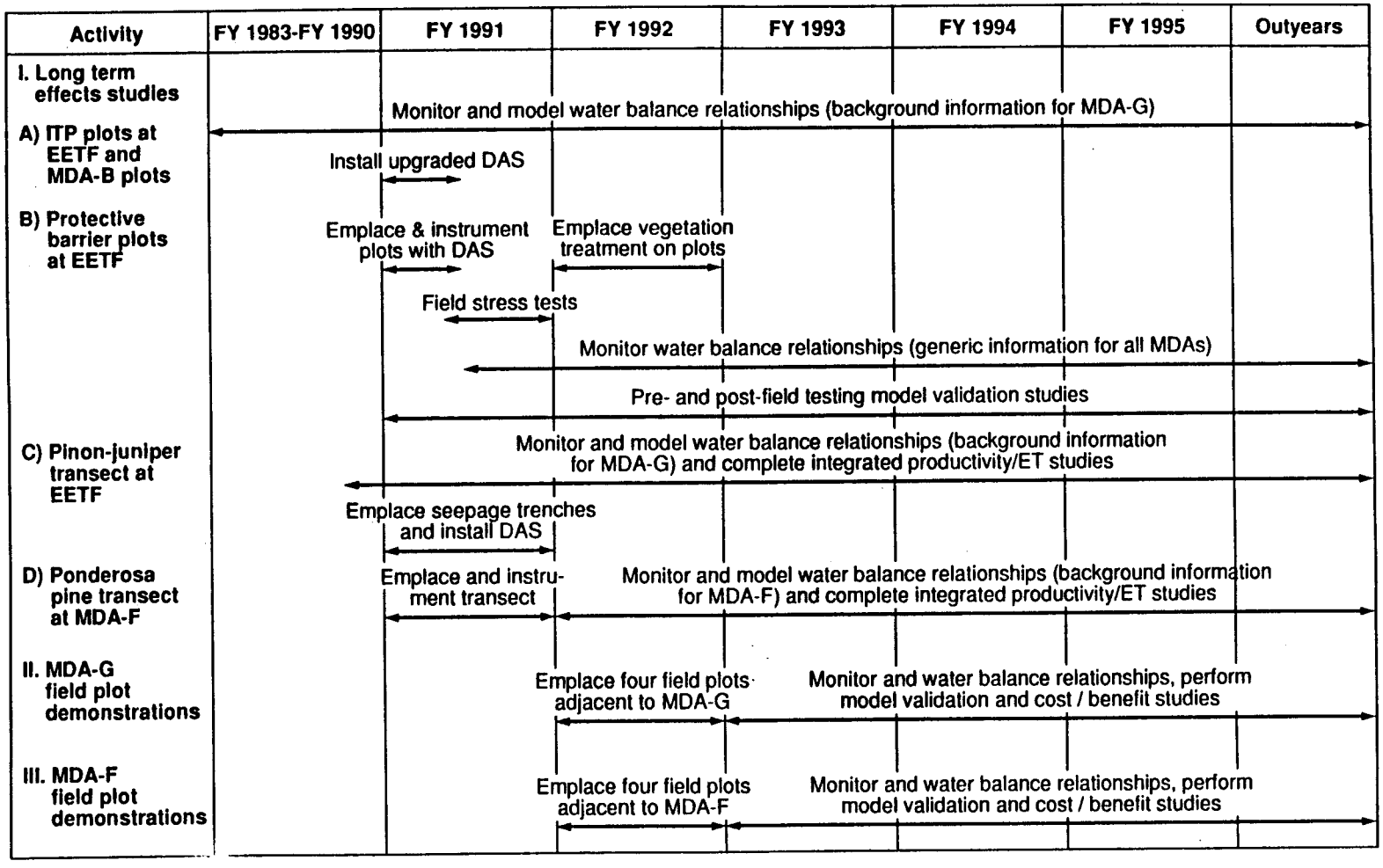


Figure D-1. Milestone chart for pilot studies.

sites and (2) integrate satellite natural area studies and results from vegetated demonstration plots (those at MDAs G and F) so that the design and functioning of cover designs can be evaluated in a regional model.

The complex nature of the program (Figure D-1) can be represented by a conceptual flow chart (Figure D-2) that shows the interdependence of modeling and field studies. Data from the ITP plots are essential to designing further studies of the water balance in cover systems, and it will be essential to maintain these two studies to obtain long-term data bases on the performance of the cover technologies being tested at these two sites.

Weather variability from year to year is an important complicating factor at Los Alamos, as are the changes in vegetation that result from climate variability. Not only is the amount of precipitation important, but seasonal distribution and very-short-term precipitation rates can have a profound effect on the water balance. During the 5 years that the pilot study at MDA B has been operating, significant changes have occurred in the vegetation. These changes affect run-off interception and evapotranspiration and thus affect the soil's capacity to store water and produce seepage. Preliminary comparisons between the evapotranspiration rates at MDA B and the piñon/juniper woodland study area show that evapotranspiration is higher in the late winter and early spring in the woodland.

3.0 DESCRIPTION AND HISTORIES OF WASTE USE IN THE STUDY AREAS

Much of Los Alamos County is located on the Pajarito Plateau, which extends from the eastern flank of the Jemez Mountains in north-central New Mexico. The plateau occupies about 47% of the land area of the county between 6,800 and 8,000 ft, and 32% of the plateau is occupied by land above 8,000 ft. Changes in elevation and orientation of topographical features exert a strong influence on local precipitation and climate, which, in turn, influence the distribution of soils, flora, and fauna. MDAs from both ends of this water balance/topographic continuum were chosen to bracket the final design recommendations and potential risks of containing waste in place.

3.1 MDA F (PRS 6-007)

MDA F was chosen as a study site because it has high elevation (7,575 ft) and precipitation and lies in a ponderosa pine forest typical of disposal areas located in the western portions of the Laboratory site.

MDA F is located on Two-Mile Mesa between two tributaries of the northern branch of Pajarito Canyon (Rogers 1977, 0216) at a distance of approximately 1,500 ft from either canyon and about 45 ft above the canyon floors. Native vegetation consists primarily of ponderosa pine and blue and black grama. Although the sites' boundaries are not strictly defined, MDA F contains two waste sites inside fenced areas (Figure D-3), both of which are located immediately north of Two-Mile Mesa Road (1.3 mi east of the intersection of Two-Mile Mesa Road and West Road). It is believed that another landfill lies just outside these fenced areas. An aerial survey conducted in the 1940s indicates that this landfill is about 40 by 70 ft (IT Corporation 1988, 0329).

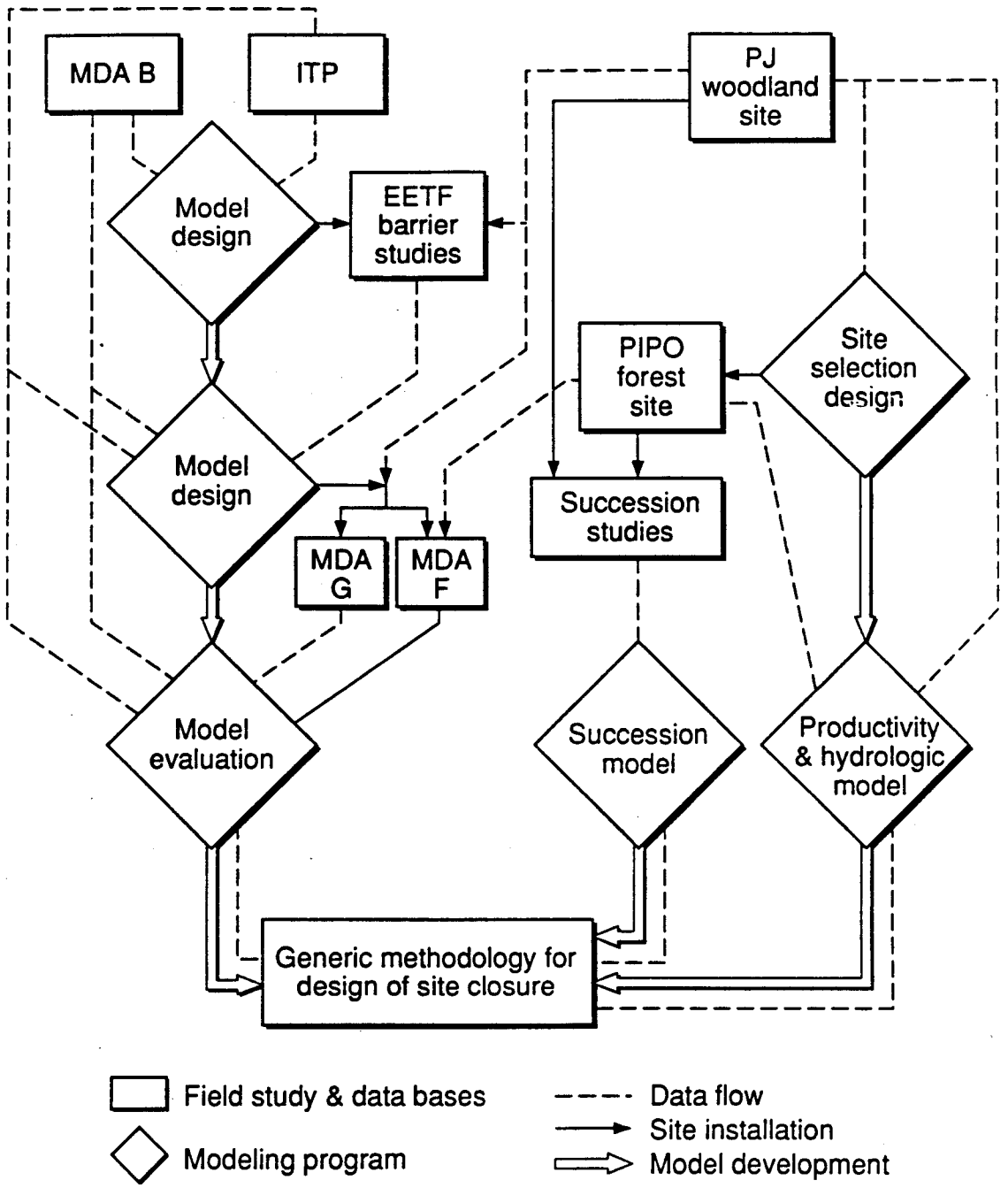


Figure D-2. Interdependence of field and modeling studies in pilot study program.

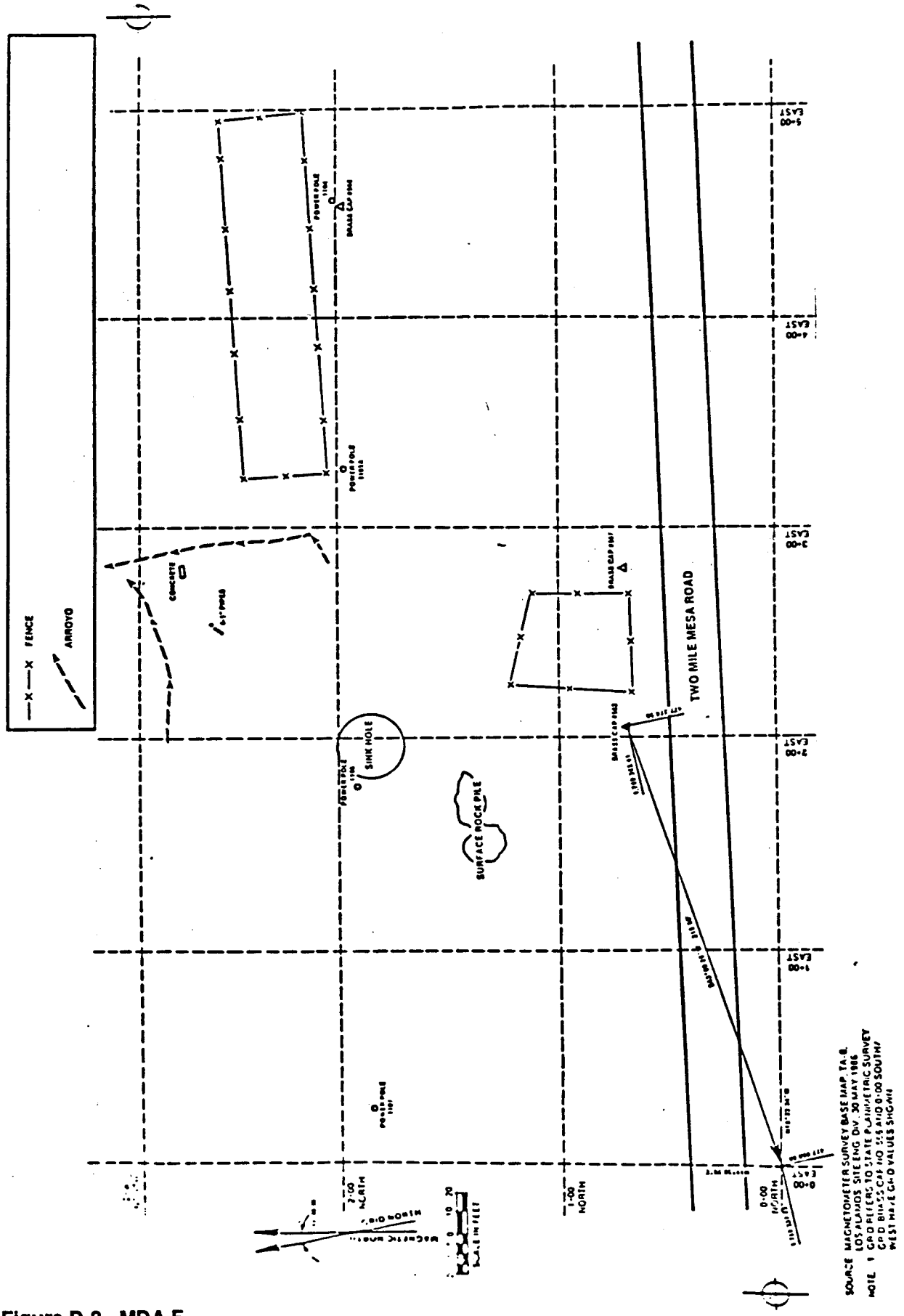


Figure D-3. MDA F.

MDA F was established about 1946 and functioned as a disposal site through 1954. The waste includes shapes, squibs, detonators, spark gaps contaminated with high explosives, and blocks of high explosive, as well as construction and equipment debris contaminated with depleted uranium. Some debris may also be contaminated with ^{90}Sr and ^{137}Cs.

3.2 MDA G (PRS 54-00)

MDA G was chosen as a study site because it has low elevation (6,650 to 6,890 ft) and precipitation and lies in a piñon/juniper woodland typical of the disposal areas located in the eastern portions of the Laboratory site. MDA G is the main active site for storage and disposal of radioactive waste at the Laboratory (Figure D-4). MDA G is located on Mesita del Buey, which is bounded by Cañada del Buey on the north and by Pajarito Canyon on the south (Rogers 1977, 0216). The native vegetation consists of piñon, one-seed juniper, and blue grama.

MDA G is used for disposal of wastes contaminated with radioactivity having less than 100 nCi/g of transuranic wastes. The first landfill trench was dug in 1957, and, by 1977, the disposal area had grown to 64 acres; 100 additional acres are currently dedicated for future expansion. The storage and disposal facilities at MDA G include trenches, shafts, pits, pads, and storage buildings of varying dimensions (IT Corporation 1988, 0329; Rogers 1977, 0216).

The principal radioactive wastes emplaced at MDA G are plutonium, uranium, tritium, and fission products. From 1971 to 1983, solid waste contaminated with transuranic radionuclides at activity levels greater than 10 nCi/g (greater than 100 nCi/g for ^{238}Pu has been stored so that it can be retrieved and sent to a permanent repository when one becomes available. In 1983, the limit on the level of activity for all transuranic waste stored for retrieval was changed to greater than 100 nCi/g. This disposal area also serves as a disposal site for mixed waste, and, in addition, has received wastes containing asbestos and polychlorinated biphenyls.

3.3 Demonstration of Integrated Test Plot Landfill Cover

In the spring of 1984, the Environmental Science Group (EES-15) began an integrated test plot demonstration at the EETF, a 20-acre field test facility located about 2 mi west of MDA G. Two types of cover design were tested: a conventional landfill cover design similar to that already being used by the Laboratory and the waste management industry (Jacobs et al. 1980, 0330) and an improved design developed by the Laboratory (Figure D-5).

Investigators installed four demonstration plots, two for each type of cover, at the EETF during the spring and summer of 1984 (DePoorter 1981, 0045) and provided instrumentation (Figures D-5 and D-6) to measure and record all precipitation falling on the plots, run-off, soil water storage, and seepage. The amount of seepage was determined by measuring leachate collected by drains that had been installed in the plots. Except for a small amount of water added to the plots in mid-1984 to aid in establishing vegetation, the plots received only natural precipitation during the course of the study. In both cover designs, the technology for controlling erosion caused by soil water consisted of covering 60% to 70% of the plots' surface with gravel (<0.75 in. in diameter) and covering the remainder of the surface with blue grama and western wheat grass. A dominant downhill slope of only 0.5% was used

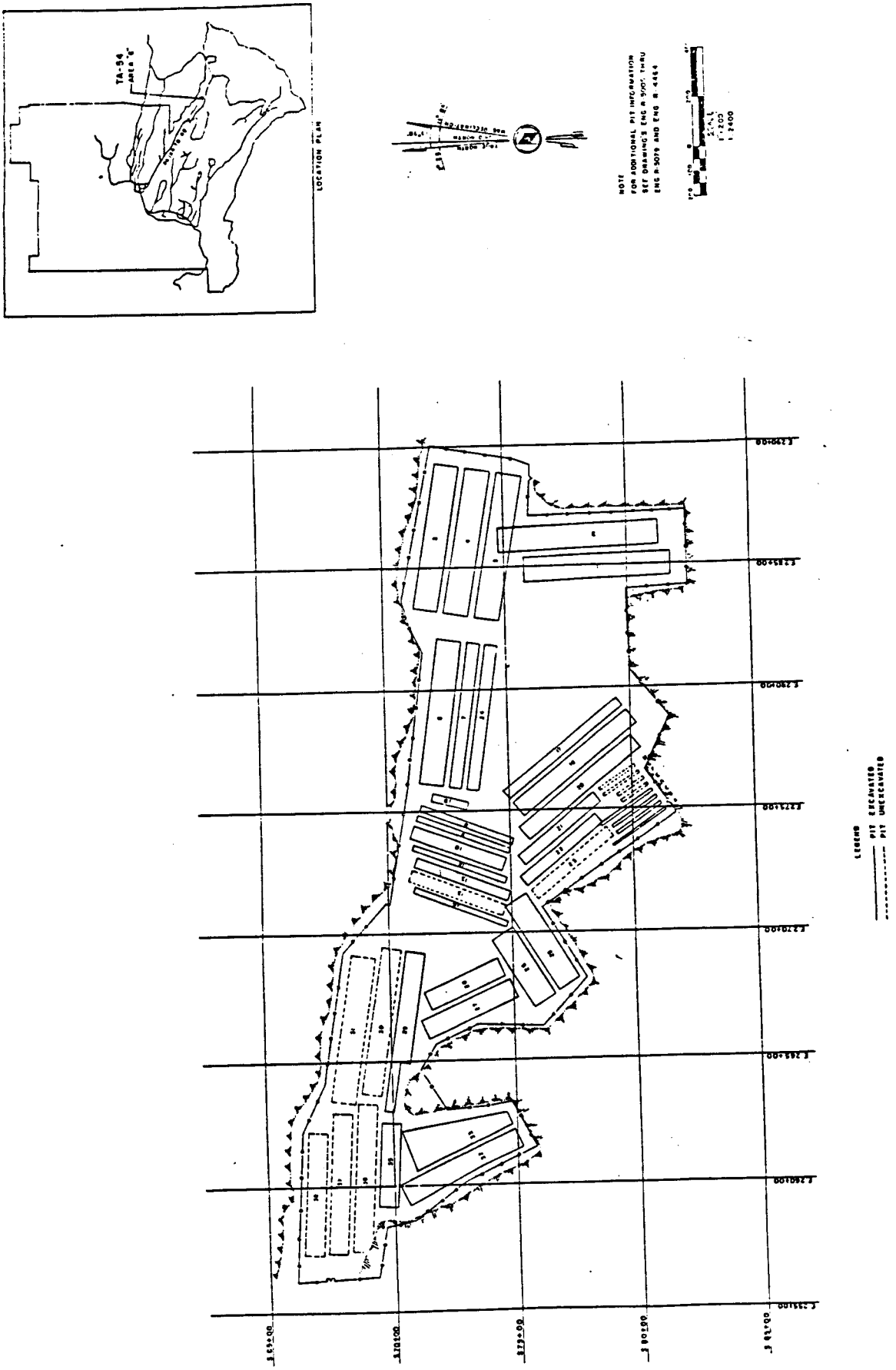


Figure D-4. MDA G.

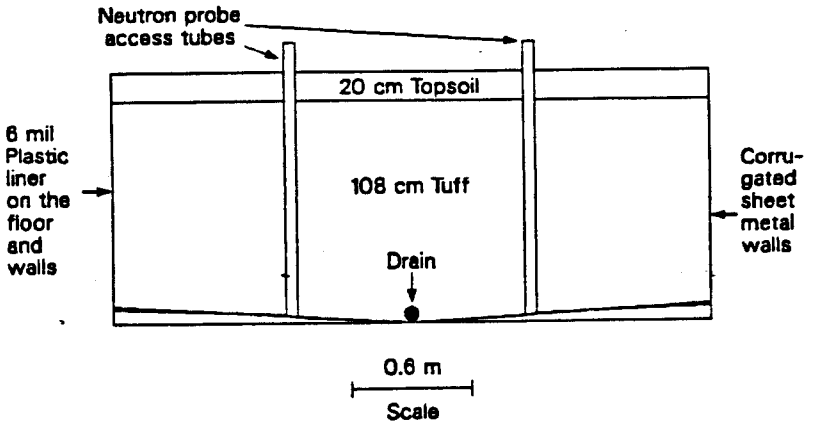


Figure D-5. Conventional landfill cover design in the ITP experiment.

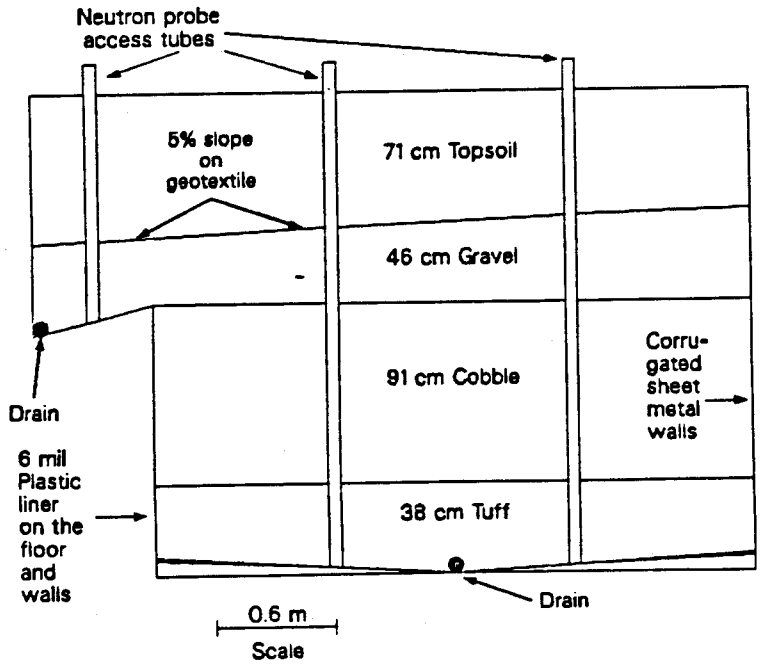


Figure D-6. Improved landfill cover design in the ITP experiment.

on the plot surfaces to ensure that little or none of the rainfall would run off over the course of the experiment (both to maximize the potential for percolation and to simplify estimating the other parameters in the water balance equation). Each plot was designed to measure run-off (Nyhan et al. 1984, 0167).

The plots with the conventional landfill cover profile (Figure D-5) were 10 by 35 ft and consisted of 8 in. of topsoil (Hackroy sandy loam, a lithic aridic haplustalf belonging to the clayey, mixed, mesic family) placed on top of 43 in. of crushed tuff backfill, both of which have been described in earlier reports (Abeele 1984, 0002; 1984, 0003; 1984, 0004; Nyhan et al. 1984, 0167). In an actual waste disposal site at Los Alamos, the crushed tuff backfill beneath a depth of about 39 in. would normally contain low-level radioactive wastes.

The plots with the improved cover design were 10 by 35 ft at the surface and contained provisions for managing any water that might penetrate the cover and for controlling intrusion by plant roots and animals (Figure D-6). From the surface downward, a 28-in. layer of topsoil (Hackroy sandy loam) was emplaced over 18 in. of gravel (6.02 to 0.04 in. in diameter) to allow water storage in the topsoil and to form a capillary barrier that would impede the vertical inflow of precipitation. A high-conductivity (0.079 m/s) geotextile was used to maintain a sharp interface between the soil and gravel layers. The opening size between the polypropylene yarns of this fabric ranged from 300 to 850 μ. A 5% lateral slope (across the 3.05-m width of the plot) on this interface and a large difference in the saturated hydraulic conductivities of these two layers were expected to cause the downward flow of water to have a strong lateral flow component and to divert soil water into the overhang (upper) drain system in these plots (Figure D-6). The cobble layer making up the biointrusion barrier at the bottom of the landfill cover consisted of a 91-cm-deep layer of cobble about 4 to 12 in. in diameter (Figure D-6). This layer was underlain by 15 in. of crushed tuff backfill. Based on previous studies (Hakonson 1986, 0115), the cobble layer was expected to minimize plant root and animal intrusion.

3.4 MDA B (PRS 21-015)

MDA B (Figure D-7) is 6-acre area that lies at elevations between 7,200 ft (to the west) and 7,100 ft (to the east) on a narrow, eastward-trending mesa approximately 100 ft from a canyon tributary to Los Alamos Canyon. It is located south of DP Road, approximately 1,600 ft east of the intersection of DP Road and Trinity Drive, east of an old trailer court area and west of the developed portion of TA-21. The native vegetation consists mainly of piñon, one-seed juniper, scattered ponderosa pine, and blue grama.

MDA B is a series of pits. In the 1940s, chemical wastes were buried primarily in slit trenches 35 to 48 in. deep, 24 in. wide, and of varying lengths. Other trenches (12 ft deep, 15 ft wide, and 300 ft long) were also used. Unlike the current practice of layering waste in pits, the pits were filled with waste and were then covered by fill material. Shortly after MDA B was closed in 1947, subsidence occurred over the pits, which was remedied by using the area for disposal of noncontaminated concrete and soil from construction sites. Around 1966, the western two-thirds of MDA B was covered by a layer of asphalt. It is now leased by DOE to Los Alamos County for storing privately owned boats and recreational vehicles.

Approximately 90% of the contaminated wastes consisted of paper, rags, rubber gloves, glassware, and small metal apparatus. The originators of the waste had placed these materials in cardboard boxes sealed with masking tape. The rest of

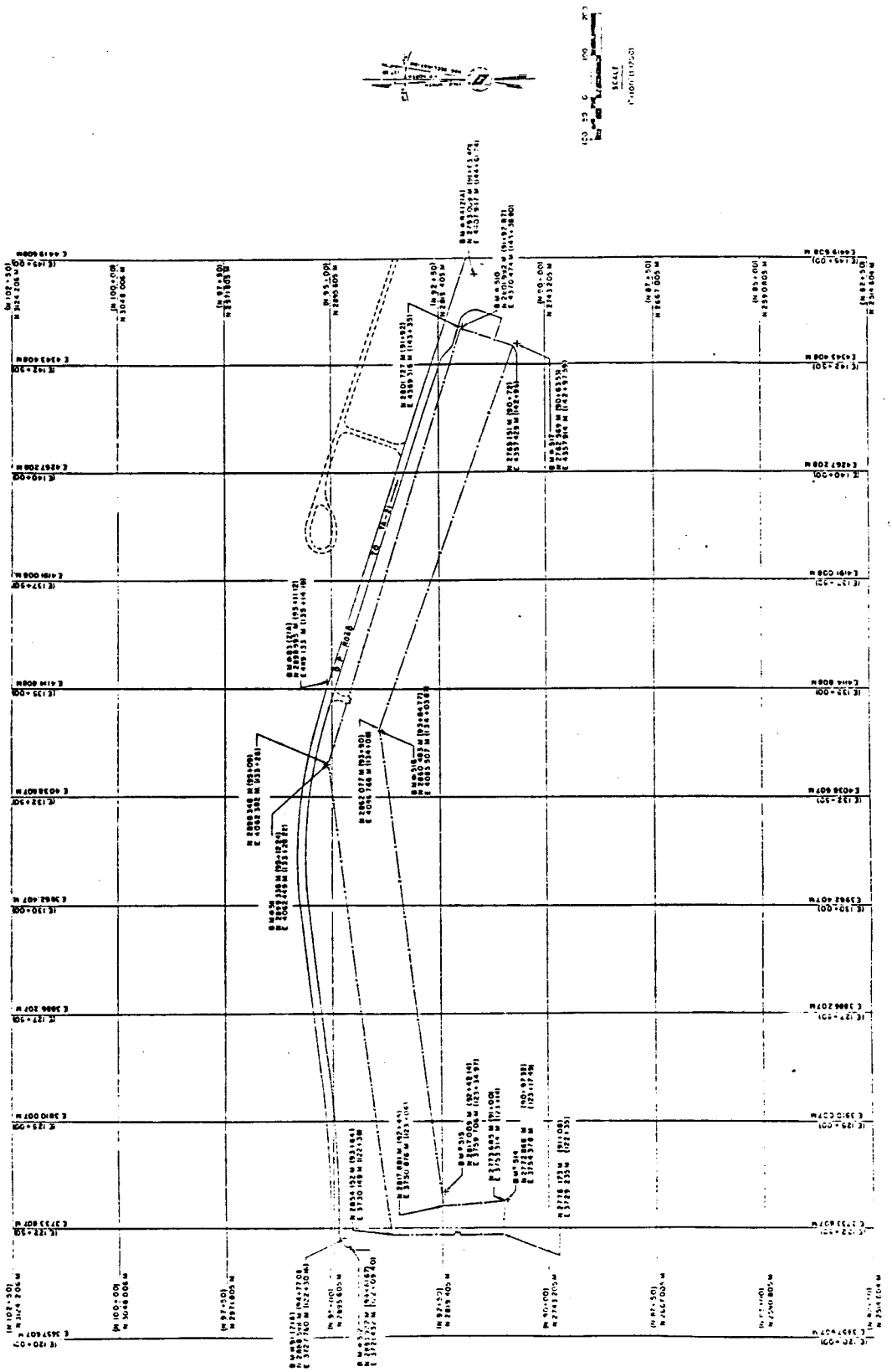


Figure D-7. MDA B.

the material, which consisted of metal, was placed in wooden boxes or wrapped in paper. In addition, large quantities of wood from temporary storage cabinets, several live storage batteries, contaminated or toxic chemicals, and at least one truck contaminated with fission products from the Trinity test are buried at MDA B. The trenches also contain old bottles of organics, perchlorates, ethers, and other organic materials. The contaminants consist of all types of radioactive materials used at the Laboratory. Some of the known radionuclides include plutonium, uranium, americium, cerium (radioactive lanthanum), and actinium.

Between 1947 and 1982, considerable natural plant succession occurred on the unpaved portion of MDA B, resulting in a plant cover consisting of trees, grasses, and shrubs. This vegetation was removed in 1982, and a new landfill cover, a portion of which contained a gravel/cobble biointrusion barrier, was emplaced in 1984.

In addition to its age, MDA B is distinguished by having been the object of more detailed postclosure studies over the past 35 years than any other site. It is further distinct because a greater variety of closure treatments have been used there than at any other MDA. These treatments range from the application of asphalt on the western two-thirds of the site in 1966 to the resurfacing of the exposed area with crushed tuff and addition of a small section of cobble/gravel biobarrier in 1982.

Over the past 10 years, a continuing series of ecosystem investigations has been conducted at MDA B with the support of the National Low-Level Waste Management Program and the EPA's Land Pollution Control Division, Contaminant Branch. A common objective of all these studies is a deeper understanding of the ecosystem processes that affect the containment of hazardous and radioactive materials disposed in near-surface soils and covered by various types of landfill.

In 1987, the surface demonstration studies at MDA B were modified to focus on the tradeoff between installing erosion control devices and minimizing seepage below the trench cap. The pilot studies were modified to investigate the effects of surface mulches, vegetative cover, and soil profile design on site water balance. Twelve plots were installed on the site, four each on the eastern, central, and western areas (Figure D-8). The configuration of these plots was the same as that used in previous studies at the Laboratory so that existing data bases and models could be used during the analysis and subsequent design phases of the overall demonstration project. Each plot (10 by 36 ft) was oriented so that its long axis was parallel to the slope of the site and was bordered to prevent overland flow of run-off from entering the plot. A collection system was installed in each plot to monitor total run-off after precipitation events and to allow transported sediments to be sampled. Three access tubes were installed in each plot to permit the use of a neutron moisture probe to measure soil moisture. In each of the three areas, two plots had a vegetative cover of shrubs (rubber rabbitbrush, *Chrysothamnus nauseosus*) and two had a cover of mixed grasses and forbs. One plot from each of these pairs was treated with a surface gravel mulch, which was applied at 13 kg/m^2. The vegetative canopy cover and ground cover (gravel, litter, and plant crowns) were measured periodically during the growing season.

By 1990, when the pilot studies project of the ER Program was initiated, the MDA B cover demonstration study was already providing an invaluable data base for use in modeling and site design.

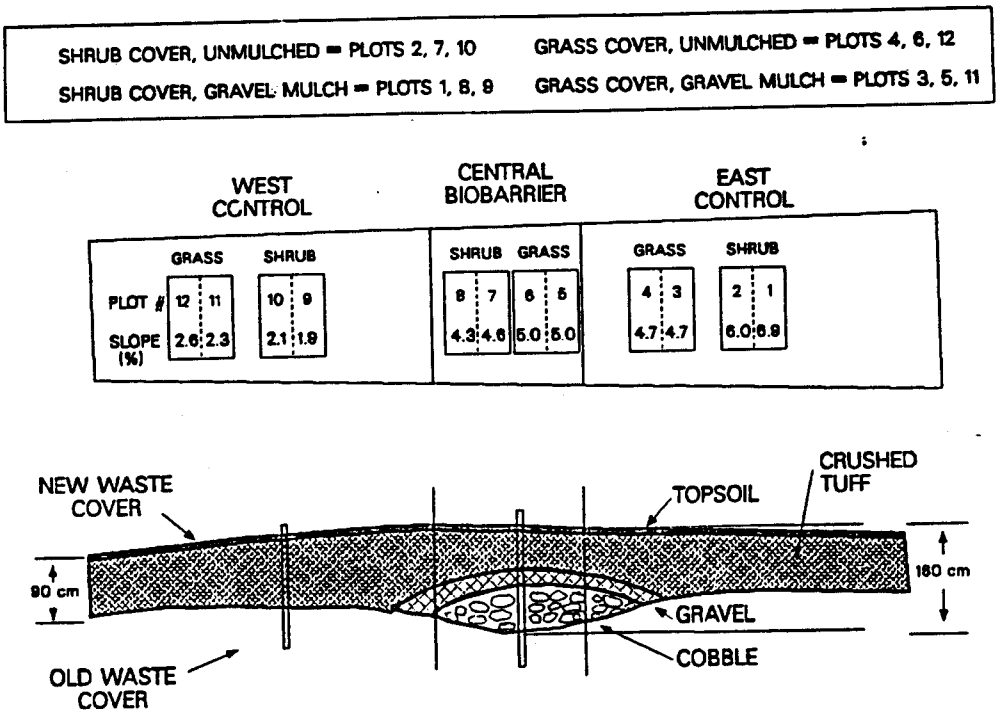


Figure D-8. Plan layout and cross-section of MDA B.

3.5 Long-Term Pilot Study of the Piñon/Juniper Woodland

The purpose of establishing the Mesita del Buey piñon/juniper woodland study area is to provide an opportunity to study how natural woodland ecosystem processes affect the hydrology of waste disposal sites and how effectively they preserve the integrity of the disposal site. The results will be used in all pilot studies at the Laboratory that address the issue of maintaining site integrity after active maintenance has been discontinued. The woodland site was established in November 1987. A transect 330 by 20 ft was laid out in a vigorous stand of piñon/juniper woodland between the office building at TA-51 and the EETF.
Figure D-8. Plan layout and cross-section of MDA B.

The major waste disposal area at Los Alamos (MDA G) is located near the pilot study area in the same woodland community type. Other disposal sites (e.g., MDA B) are also in the same vegetative zone. In the postmaintenance period, natural succession at these MDAs will most likely result in woodland vegetation.

Ongoing projects at the Mesita del Buey study area in the last 4 years have focused on measuring selected water balance components (precipitation, soil water storage, interception of precipitation by the canopy, and evapotranspiration rates). Access tubes to permit measuring soil moisture with a neutron moisture probe (down to a depth of 10 ft) have been installed about every 30 ft. Soil moisture is measured every 2 weeks. In addition, Laboratory collaborators at Boston University have studied primary productivity and population dynamics at this site.

In the summer of 1991, four run-off plots were established adjacent to the woodland transect described above. These plots are 10 x 35 ft wide and are representative of intercanopy areas in a piñon-juniper woodland. Natural vegetation covers each of the plots but ranges from that representative of a very disturbed site to that of a

relatively undisturbed site. From these plots, investigators measure the volume of run-off and sediment associated with different precipitation events. These data are extremely valuable because they allow better characterization of run-off dynamics and therefore better characterization of contaminant movement from these types of systems. They also allow for establishing parameters, validating data, and developing contaminant movement models for the Pajarito Plateau.

The vegetative features of the study area have been mapped (Figure D-9). Piñon dominates the site; piñon seedlings are clustered under the canopies of the mature trees, both piñon and juniper. Shrubs are mountain mahogany and shrub oak; subshrubs include yucca, prickly pear, and sagebrush species. Common grasses include blue grama, mountain muhly, and muttongrass. These plant species are typical of local piñon/juniper communities.

4.0 PILOT STUDIES

The pilot studies performed by the Environmental Science Group (EES-15) will continue to provide data to support the remedial alternative of capping MDAs and leaving the wastes in place. The overall objective is to demonstrate that capping is cost-effective and protective of human health and the environment.

4.1 Approaches for Remediating Contaminated Soils

Because protective barriers currently have a high probability of success at a low cost compared with other candidate technologies, this technology has been chosen for evaluation in pilot-scale field tests.

Barrier technologies are cheaper than exhuming and treating waste because they permit some types of wastes to remain in place. A considerable portion of the ER Program's budget could be saved if the Laboratory can safely dispose of wastes in place. Ordinarily, natural precipitation and recharge drive the movement of contaminants from the unsaturated zone; however, protective barriers, which are constructed of naturally occurring materials, can reduce the amount of recharge reaching a waste source, thereby reducing contaminant migration, and thus can be used for long-term isolation of waste. Barrier technologies are not suitable for use at unstable waste sites or at sites in which underground voids are found, and further studies must be conducted to determine whether fluvial processes erode barriers and how well barriers perform over the long term.

Usually, protective barriers are placed over or around waste units. They usually include (1) some form of outer matrix to prevent plants and animals from intruding into wastes and to reduce erosion of the landfill cover and (2) a vegetative cover to reduce soil erosion and return moisture to the environment via plant transpiration. To achieve these objectives, it is proposed to use both modeling studies and field demonstrations to identify the key factors that influence site integrity and then to determine how to manage these factors and implement site-specific designs (Figure D-10).

The key factors are most likely to be the characteristics (porosity, unsaturated and saturated hydraulic conductivities) and geometry (depths, slopes, lengths) of soil layers, the length of the slope, the condition of the soil surface (mulched or bare soil), the characteristics of the vegetation [extent of biomass, seasonality of activity

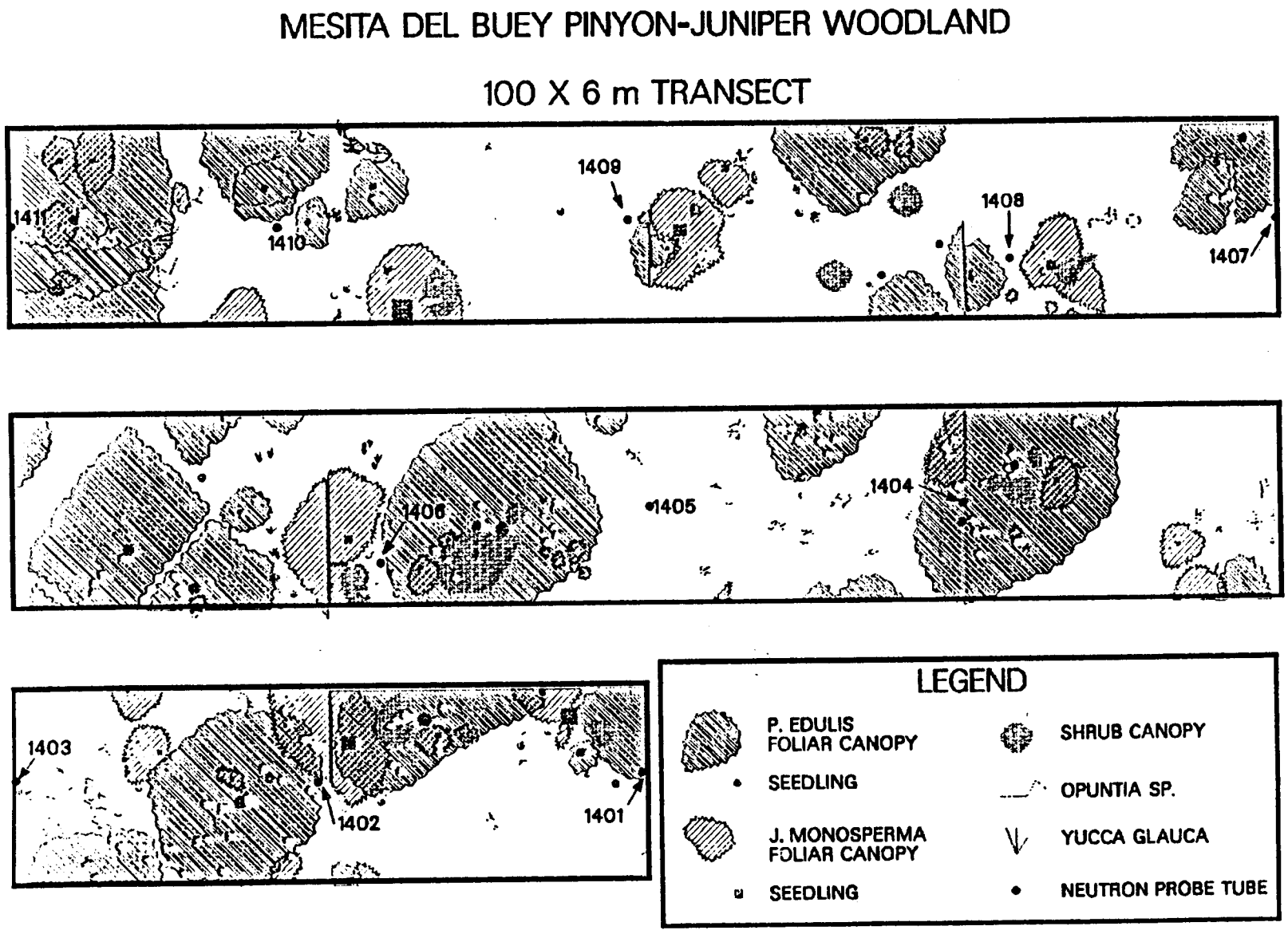


Figure D-9. Piñon-juniper transect at the EETF

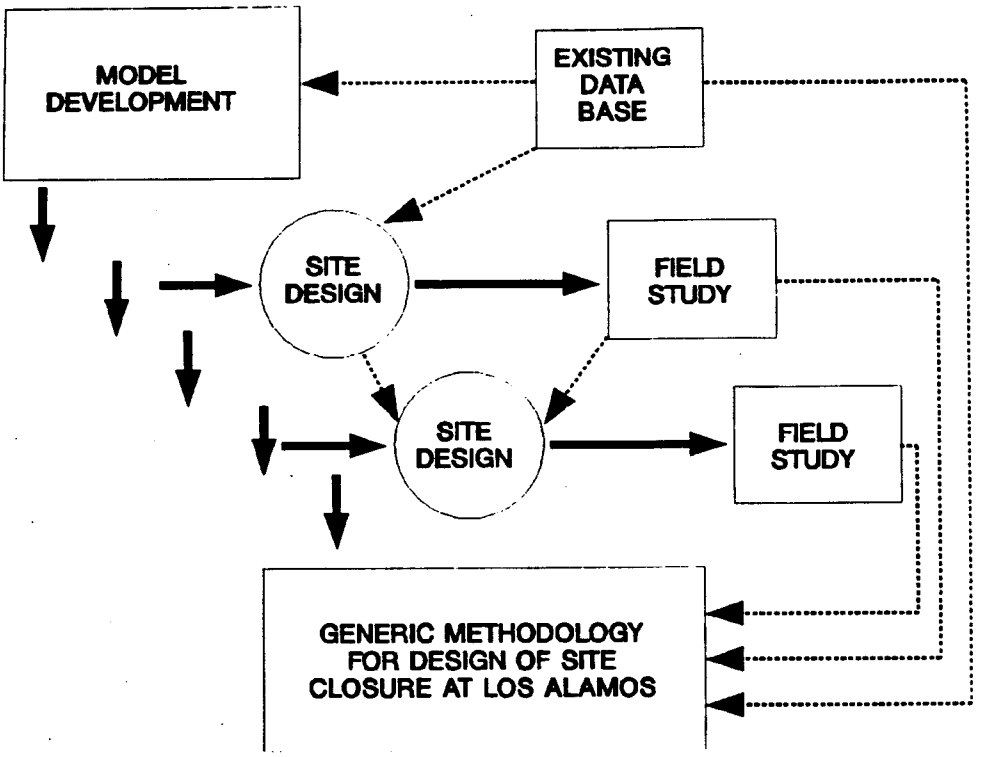


Figure D-10. Conceptual organization of modeling and field studies for developing a generic site closure methodology.

(phenology), the structure of the canopy, the ability of the plant base to cover the soil surface], and climatic characteristics across the elevational gradient found at the Laboratory (amounts and seasonal distribution of precipitation, temperature regimes). Other factors may emerge as significant early in the program.

If there are insufficient data on these factors or on the effects of interactions between them, particularly on a site-specific basis, specific pilot studies will be initiated. Based on current understanding of data needs, fundamentally important studies on site hydrology and long-term ecosystem function will be initiated at the EETF, MDA G, and MDA F. These studies will be combined with field tests of the Laboratory's conventional cover design and of the cover design developed by EPA and will build on experience at MDA B and the EETF. Additional smaller field studies may be initiated at the sites of long-term studies as new issues emerge during the course of the program. For example, short-term studies that may be undertaken as part of ongoing studies include a study that uses organisms in the soil crust to investigate surface stabilization and a study to identify microenvironmental phenomena that inhibit animal intrusion.

The modeling used to identify data needs and prioritize additional studies will be expanded into a program of evaluating existing hydrologic and ecosystem models and calibrating them to local environmental conditions. The results of the field studies may indicate a need to further develop existing models. The modeling program will assist in the design of certain aspects of pilot studies in the field. Finally, both the modeling program and the data bases obtained from these pilot studies will be used to develop a generic methodology for site closure at Los Alamos (Figure D-10).

4.2 Technical Objectives

Water balance components of the various shallow-land burial scenarios described above will be determined as a function of time. If attention is focused on net rates and amounts and if one-dimensional movement of water in the soil profile is considered, the following equation can be used to represent a simplified water balance:

$$S = P - Q - ET - I - L, \qquad (1)$$

where S = change in soil water storage, P = precipitation, Q = run-off, ET = evapotranspiration, I = interflow, and L = seepage or percolation.

The seepage term (L) is a measure of the total precipitation that penetrates the entire landfill cover and infiltrates the underlying wastes. The interflow (that portion of water that flows laterally through the soil) term (I) involves the subsurface water that is diverted horizontally in the protective barrier and does not penetrate the landfill cover. Thus, the technical objectives of the field testing of shallow land burial designs (left side of Figure D-2) and the long-term natural vegetation studies (right side of Figure D-2) can be listed as

- measuring the water balance components to evaluate spatial and temporal variabilities in the integrity of closure designs;
- measuring the water balance components to evaluate long-term dynamics in natural systems;
- measuring successional trends in vegetation, soils, soil organisms, and burrowing fauna at Los Alamos sites; and
- developing standardized, cost-effective field methods for monitoring pilot studies and selecting in-place stabilization.

The results of the field tests will be used to calibrate water balance and other hydrologic models, which, in turn, will be used in the generic design methodology for site closure (Figures D-10 and D-2). These models will initially include hydrologic models such as CREAMS (Lane 1984, 0138; Nyhan and Lane 1986, 0159), as well as more sophisticated models currently under development that perform two- and three-dimensional modeling of water transport in the unsaturated zone. Currently, none of these models has been field-calibrated (including EPA's HELP model, with the exception of the preliminary CREAMS studies at the ITP demonstration (Nyhan 1990, 0155). Thus, the technical objectives of the modeling studies can be listed as

- identifying models for hydrologic simulation of closure designs;
- performing a sensitivity analysis to identify key factors contributing to integrity;
- calibrating models to the environmental conditions at MDAs G, B, and F; and
- predicting closure design performance.

The relevance of understanding water balance modeling results to design and remediate waste sites has been discussed (Hakonson et al. 1982, 0124; 1987, 0127; Lane 1984, 0138; Nyhan and Lane 1986, 0159; 1982, 0157). The various components of the water balance equation are coupled; therefore, to control any one component, it is necessary to modify one or more of the other components. For example, to eliminate seepage, it is theoretically possible to increase run-off and/or evapotranspiration to the level at which the seepage term is forced to zero. Although the concept appears simple, achieving control of one or more of the water balance components requires a good understanding of the very complex relationships and feedback mechanisms that compose the water balance. The use of water balance models to design and remediate landfills (Nyhan et al. 1989, 0171) offers the following advantages:

- water balance models take into account many of the climatological, hydrological, and biological factors that influence waste site integrity;
- water balance models can be used to screen various designs for effectiveness in controlling erosion and percolation; and
- water balance models can be used to estimate upper boundary conditions for subsurface water flow, which are important in estimating leachate production and contaminant transport to groundwater.

The ER Program's overall objectives for technology development can thus be summarized as

- evaluating and predicting performance at each stage,
- developing generic methodology for modeling closure designs,
- developing generic methodology for incorporating site-specific data into closure designs,
- developing conceptual models of managing successional trends that can be used to modify designs at Los Alamos, and
- developing generic methodology for defining long-term maintenance and monitoring needs.

5.0 FIELD INSTALLATIONS AND SAMPLING PLANS

The water balance components of the various shallow-land-burial scenarios and the natural systems transects described above will be determined as a function of time, using the field demonstrations described in Sections 5.1 and 5.2 and the specific sampling plans described in Section 5.3.

5.1 Protective Barrier Site Installations

In general, field plots (10 by 35 ft) for examining water balance in shallow-land-burial scenarios will be installed using procedures that have become standardized over

many experiments and demonstrations at Los Alamos. The ITP demonstration serves as a model system for measuring all water balance components except evapotranspiration.

Plots will be constructed with impermeable walls and footings and with drainage and collection systems for both laterally and vertically transported moisture. A system of borders and gutters on the surface of the plot will allow collection of surface run-off. Each plot will be instrumented with neutron probe access tubes and/or time domain reflectrometry probes to permit measurement of soil moisture.

The installations at each site are briefly described below.

5.1.1 MDA B

The pilot study at MDA B is documented in detail in the work plan for TA-21 [Appendix Q in the 1990 IWP (LANL 1990, 0144)]. Briefly, this pilot study consisted of 12 study plots (10 by 35 ft) that were installed in 1987 on an inactive waste site at which two different soil profiles had been used in the trench caps. Four surface treatments (grass/gravel mulch, grass/no mulch, shrub/gravel mulch, and shrub/no mulch) were used on plots at each of three locations on the site. Soil moisture, run-off, precipitation, and surface conditions have been monitored since 1987; sediment transport was monitored between 1987 and 1989 on some or all of the plots.

Preliminary results show that the presence of a gravel/mulch cover reduces run-off and sediment transport because the gravel/mulch cover increases infiltration, which, in turn, increases the biomass and thus evapotranspiration. Shrub plots tend to have a drier soil profile than that of the grass plots, resulting in greater storage capacity for soil moisture during spring snowmelt.

An upgraded data acquisition system for the pilot study at MDA B was designed in FY91. Installation will be completed in FY93. Upgrades at the site include automating the measurement of run-off volume. Tests of a sediment transport system for use on small plots were under way in late FY92.

This site will be monitored until 1998 to provide a long-term data base of responses to variations in the local climate.

5.1.2 Pilot-Scale Studies of Protective Barrier Performance at the Experimental Engineered Test Facility

5.1.2.1 ITP Demonstration

Section 3.3 provides detailed information on the specific test conditions, soil types, plant cover, and plot designs used in the ITP demonstration. Generally, information obtained from this experiment can be used as background information for MDA G because the soil types, tuff backfill, plant cover, and natural precipitation are similar to those found at MDA G. However, in the ITP demonstration, the essentially flat surfaces of the field plots preclude run-off from these plots, which, considering the water balance equation presented in Section 4.3, means that the seepage term is maximized.

5.1.2.2 Protective Barrier Landfill Cover Plots

In FY92, the Environmental Science Group (EES-15) emplaced protective barrier landfill cover plots to examine water balance relationships for four different landfill cover designs containing engineered barriers. These field experiments were performed at the EETF and were designed to be similar to experiments currently being performed at the Universities of Hamburg, Munchen, Darmstadt, and Karlsruhe, Germany, as part of the DOE's International Technology Exchange and ER programs.

The variables in these plots are the thickness of the protective barriers, slope, and profile components (hydraulic barriers or capillary barriers). Four landfill cover designs are being tested in 1- by 10-m plots with downhill slopes of 5%, 10%,15%, and 25%. The configuration of the conventional design, which matched the design of shallow land burial trench caps historically used at Los Alamos, consisted of 15 cm of a loam topsoil underlain by a 76-cm layer of crushed tuff backfill. The second design was similar to that required for landfills by the EPA and consisted of 61 cm of a loam topsoil underlain by a 30-cm medium sand drainage layer, which was underlain by a 61-cm-deep hydraulic barrier. This low-permeability layer consisted of a mixture of sodium-saturated bentonite clay and crushed tuff backfill. The two other cover designs contained capillary barriers and differed only in the topsoil used in the top 61 cm of the profile, which was either a loam or a clay loam; this topsoil was underlain by a 76-cm layer of fine sand.

A seepage collection system was installed beneath each cover design, which consisted of a series of four metal pans filled with medium gravel and placed end-to-end in the bottom of each field plot. This layout allowed an evaluation of seepage occurring in these designs as a function of slope length. Precipitation is also measured in a 1- by 10-m plot containing four metal pans similar to those used in the seepage collection system, except that no gravel was added.

Field measurements of interflow, run-off, and soil water content in each of the 16 plots are collected, and the remaining water balance equation parameter, evapo-transpiration, is solved by difference. An automated water flow data-logging system is used to quantify the flows of precipitation, run-off, interflow, and seepage from all of the plots. This system consists of 100 100-L tanks, each of which is equipped with an ultrasonic liquid-level sensor and a 5-cm-diameter, motor-operated ball valve. Hourly liquid level measurements are routinely collected and stored with the help of a computer in this system. When the liquid level approaches the top of the tank, the computer activates the ball valve and the tank is emptied in about 25 s, resulting in the start of another filling cycle.

Because one of the goals of this experiment was to provide field data to calibrate several hydrologic models, it was necessary to measure soil water content at multiple points in space and time. Thus, soil water content is routinely monitored using time domain reflectometry (TDR) techniques every 8 h with the help of an automated and multiplexed measurement system. Volumetric water content is measured with a pair of waveguides with a length of 60 cm at each of 212 locations throughout the 16 plots. One set of waveguides was emplaced vertically in every soil layer above each of the metal pans in the seepage collection system; these waveguides allowed investigators to determine soil water inventory in four locations in each field plot. A second set of waveguides was emplaced horizontally in several soil layers to provide a more detailed picture of soil water dynamics close to the

interfaces of a few soil layers. Each TDR waveform recorded with the cable tester is stored on a computer to allow for quality assurance (QA) and quality control (QC).

Water balance data will be evaluated for each landfill cover design as functions of time and slope. The performance of the hyraulic and capillary barriers will be evaluated relative to slope and slope length and will be compared with the results of similar studies being performed throughout Germany.

In FY93, the 16 field plots will be used to evaluate water balance relationships when artificial precipitation is added to the plots. The field plots will receive precipitation that simulates a 100-year event, an amount of water designed to make the capillary or hydraulic barrier (in the protective barrier) fail. All of these plots will be devoid of vegetation and, thus, will represent a worst possible case—minimal evapotranspiration and maximum interflow and seepage.

In FY93, the same plots will be used to determine the interaction between evapotranspiration and capillary/hydraulic barriers. The field plots will receive a plant cover consisting of a dominant local plant species (to be determined but may consist of piñon, rabbitbrush, and a mixture of range grasses). The data obtained from these field plots over the long term will allow determination of

- whether evapotranspiration can reduce the stress on the capillary/hydraulic barrier, thus improving the performance of the protective barrier;
- whether plant roots have an appreciable effect on the integrity of the capillary/hydraulic barrier; and
- whether the slope of the landfill cover has any solar-radiation-related effects on the interaction between plant cover and the performance of the capillary/hydraulic barrier.

5.1.3 Field Demonstrations at MDAs F and G

The pilot study field demonstrations will consist of four proposed landfill cover plots to be emplaced in each disposal area. These demonstrations will contribute to the understanding of water balance relationships as a function of time (proposed for FY94 through the life of the task). Natural precipitation will be the input term. The most important characteristic of this final phase of the pilot studies will be the field scale of the study; the landfill cover designs will be tested on plots closer to the size of potential release sites (PRSs) than to the smaller size of the plots used for the field studies described in Section 5.1. The soil type, slope, and profile components will be taken from the designs that performed the best at MDA B and at the EETF (Sections 5.1.1 and 5.1.2). Plant cover will be a variable in these field studies and will be chosen to match plant species native to each location and contained in the long-term woodland transects at each MDA (ponderosa pines and native grasses at MDA F and piñon and native grasses at MDA G). Thus, every variable in the water balance equation will be tested in each of four landfill cover designs adjacent to each disposal area, and testing of individual components and long-term testing will be performed in the other portions of the pilot study.

5.2 Natural Systems Sites

The long-term natural systems pilot studies at the EETF and MDA F will evaluate water balance relationships over time in a natural ecosystem. The piñon/juniper transect at the EETF was improved in 1991 with the addition of plots for determining run-off and sediment movement. A hillslope hydrology study was implemented in the summer of 1992 at TA-69 (adjacent to MDA F). This site is representative of a ponderosa pine community that over time will establish itself at MDA F. Specific goals for the long-term pilot studies of natural systems over the next 8 years are to

- complete the water balance studies at the sites by installing means to measure run-off, infiltration, and lateral flow over selected portions of the site and to continue measurement of evapotranspiration and storage of soil water and

- complete the integrated ecosystem studies of productivity and evapotranspiration, using both field and modeling studies, and apply the models to remediated sites to estimate long-term effects.

5.2.1 Ponderosa Pine Site at MDA F

The hillslope hydrology study at MDA F is designed to measure the major components of the water budget for a hillslope about 1 acre in size. Surface run-off is collected from a 20-m collection system laid perpendicular to the hillslope. Interflow is collected at two depths in the soil (25 and 100 cm). To collect interflow, a 14-m trench, about 1.5 m deep and 1 m across, was constructed perpendicular to the hillslope, and collection gutters were installed at the stated depths. Run-off and interflow are routed into collection wells, where the depth of water is continuously monitored, and water is removed from the wells automatically when necessary. Soil moisture is monitored using TDR technology, which is ideally suited for automatically collecting soil water data, at 36 locations on the hill slope. Neutron probe access tubes will also be established in six to nine locations to complement the TDR data. In addition, soil temperature will be continuously monitored to evaluate the impact of frozen soil on run-off dynamics. A weather station to collect data on humidity, precipitation, solar radiation, and wind speed has also been installed. Investigators plan to totally automate this field study to allow for detailed collection of water budget information. In FY93, a similarly sophisticated hillslope field plot will be established in an adjacent ponderosa pine woodland that has a much denser canopy, which will allow a determination of the impact of dense tree cover on the water budget. A similar study will also be established on a piñon-juniper hillslope at TA-51. Soils on the site have been described in detail and have been sampled to determine hydrologically important characteristics.

These data are extremely valuable because they allow for the development, validation, and calibration of contaminant transport models for conditions on the Pajarito Plateau. These models will, in turn, be linked to state-of-the-art risk assessment methodologies, allowing for a more precise and less conservative estimate of risk, potentially saving millions of dollars in unnecessary remediation.

5.2.2 Piñon-Juniper Site at MDA G

The piñon-juniper transect at the EETF was supplemented in 1991 by upgrading four erosion plots (10 by 35 ft) already established in an adjacent area at TA-51. These plots were part of the Water and Erosion Prediction Project conducted by the USDA in 1988, in which data were obtained on run-off and erosion under simulated rainfall conditions. Both the 1988 data and the data collected under conditions of natural rainfall (starting in 1991) will be used in developing models of surface hydrology for the woodland.

The site has typical intercanopy vegetation (grasses, forbs, and low woody perennials) adjacent to areas with trees and thus is representative of intercanopy patches in the woodland. Two of the plots represent undisturbed conditions and have high vegetative cover. The two remaining plots were completely denuded in 1988 and represent highly disturbed conditions. These differences in cover conditions allow assessment of the impact of disturbance on run-off and erosion. A detailed topographic survey of the plots was performed, and the plots were instrumented with an automated TDR system to measure soil moisture. Adjacent to one of the plots, a pit has been dug and TDR probes have been inserted horizontally into the underlying soil and tuff. The tuff is highly fractured, and these fractures are filled with soil. The investigators have instrumented one of these fractures in an effort to measure water movement through the fracture.

A run-off collection system was installed in 1991 on each plot. Run-off and sediment transport were monitored after each precipitation event throughout the winter of 1991-92 and summer of 1992. Surface vegetative features were recorded photographically in 1991 and again in 1992. The run-off and sediment collection system has been redesigned, and the upgraded system is being installed in 1992 and early FY93. This system will allow collection of hydrograph data for each plot during run-off events and will also reduce manpower needs for collecting data on total solids transported. A tank collection system will remain in place for total run-off collection. The data collected in this piñon-juniper woodland are extremely valuable because they allow better characterization of run-off dynamics and therefore contaminant movement from this kind of system. They also allow for the parameterization, validation, and development of contaminant movement models on the Pajarito Plateau.

Plans for installing a hillslope run-off and sediment collection study over a broader area are under way. The area for this study will be somewhat larger than the erosion plots and will be installed on a gradual slope with woody vegetation. Techniques developed for the ponderosa pine hillslope study will be used at this site.

A detailed topographic survey (0.5-ft contours) of the piñon-juniper transect was conducted in FY92. Each tree was tagged and mapped, and basal diameter and height were measured. These data are being entered into the ARC/INFO Geographical Information System (GIS) data base at ER Program's Facility for Information Management and Display (FIMAD) in FY93. This data set will form the basis for studies on variability in the woodland area and the interaction between surface variability and hydrologic response. Measurements of soil moisture along the 100-m transect in the piñon-juniper study site continued in FY92 at 2-week intervals. Additional measurements of the fine-scale variability in surface soil moisture are being taken and are being correlated with the canopy structure data obtained along the transect in FY91.

Plant physiologic measurements were obtained every 2 to 4 weeks during the 1992 growing season. These data (predawn plant water potentials, stomatal conductance, and transpiration rates) are essentials for modeling water balance in the woodland. Changes in these parameters as a function of soil moisture availability and other environmental parameters (e.g., air and soil temperatures, light availability, and nutrient status) will be required for modeling both the hydrologic regimes and site stability across the areas of interest. Measurements of these parameters will be continued in FY93. In addition, photosynthetic rates will be measured throughout the year so that parameters can be determined and a model of carbon fluxes in the ecosystem can be developed.

5.3 System Integration

Links to the FIMAD data bases are being established. The topographic and surface mapping of the woodland study site has been imported into ARC/INFO, and existing data bases will be incorporated during FY93. Initial analyses have indicated that the 10-m spacing for the 0- to 3-m-depth soil moisture measurements are essentially independent measurements. Further statistical analyses of the fine-scale measurements (TDR and canopy gap fractions) will be performed in FY93 to determine the characteristic scales of the surface soil moisture and vegetative covers.

In FY92, investigators made substantial progress on the overall modeling approaches for integrating the pilot studies for the purposes of developing a generic methodology for site closure and prediction of stability. The influence of canopy patches on redistribution of incoming precipitation is being modeled for the woodland community. Competition between tree species and between tree and intercanopy (grass) patches is being modeled and will be validated using data obtained from FY91 experiments that used tritiated water spikes in intercanopy patches. In FY93, the modeling effort will continue, and an initial model will be completed and tested for the piñon-juniper site. Modification of the model for the ponderosa site will be initiated.

Construction of a GIS-linked radiation budget model is underway with the assistance of contractors from Kansas University. The model is initially being developed to represent the radiation budget on the protective barrier plots (Section 5.1.2.3) on any date and time of day. This capability will allow interpretation of the movement of water and surface evapotranspiration during the FY93 experiments and modeling of the surface energy budget. This model, which will use the slope/aspect/elevation modeling capability of ARC/INFO, will be applicable to the entire Laboratory site. Because the evapotranspiration processes (both soil evaporation and plant transpiration) are driven by the energy budget, this development is essential to the overall modeling effort of the pilot studies program. In FY93, the radiation budget model will be completed and linked to the GIS. It will be applied to both the piñon-juniper and ponderosa pine study sites and validated at these areas.

5.4 Remote Sensing for Site Characterization

In FY92, Laboratory investigators collaborated with other scientists studying state-of-the-art remote sensing technology to characterize surface conditions at several PRSs. These tests are designed to show the capability of the technology and to interface with several other DOE programs. This collaboration may lead to more

efficient assessment of surface conditions for the ER Program. Its only cost to the program in FY92 was that of the staff time needed to arrange the logistics at Los Alamos. The three remote sensing projects in which Los Alamos took part are briefly outlined below.

5.4.1 High-Resolution Scanning Spectrometer

In FY92, investigators at EG&G/EM, Inc., proposed to use Los Alamos as a test site for their technology development program funded under the DOE's RDDT&E Program. The goals are to develop remote sensing techniques to detect contaminants on the soil surface and the effects of contaminant plumes on surrounding vegetation. The objectives of the FY92 test were to obtain high-resolution scanning spectrometer data over both control (clean) and contaminated sites (PRSs) and then to evaluate the potential of the technology for detecting vegetative stress. The natural system study sites (Section 5.2) are ideal control sites for such a study. The Los Alamos investigators worked with operable unit project leaders in the ER Program to select PRSs suitable for the tests and coordinated site access and safety for the tests. In May 1992, almost continuous heavy rains during the entire flight window of 10 days prevented obtaining a useful data set. EG&G plans additional flights during September 1992 and again in FY93. In FY93, Los Alamos investigators will obtain ground truth data in support of the overflights and will assist in integrating the data bases into the GIS system at FIMAD. They will also participate in evaluating the utility of the technology for remote characterization of PRSs.

5.4.2 Laser-Induced Fluoroscopy

Late in FY92, EG&G/EM, Inc., from Goleta, California, will visit the Laboratory to test laser-induced fluoroscopy instrumentation to measure the signal from uranium-contaminated soils and the chlorophyll reflectance of vegetation growing on both control and contaminated sites. This system has the potential for airborne sensing of surface contamination and localized effects on vegetation. The ER Program will assist EG&G/EM, Inc., tests by ground truthing the measurements of plant response.

5.4.3 AVIRIS Sensors

ER Program investigators have communicated with National Aeronautics and Space Administration (NASA) scientists (Dr. Chris Borel and Dr. Sig Gerstl of Los Alamos and Dr. Susan Ustin, UC Davis) about their remote sensing studies. A NASA overflight of the Laboratory by the AVIRIS sensors has been requested for late FY92. Los Alamos participants will contribute to the ground truthing for this overflight to evaluate the potential of using this technology for characterizing PRSs. The natural systems study sites will be used as controls for the PRSs. The primary responsibilities of the Los Alamos participants will be to obtain ground cover and soil moisture data. Depending on the timing of the flight, basic physiological data on the vegetation will also be collected.

5.5 Sampling Plan

This section presents the sampling plan and analytical methods for each component of the water balance equation and for determining surface characteristics. These

parameters are determined as a function of time. Several documents apply to these demonstration studies: detailed procedures (Lopez 1990, 0348), QA plans (Essington 1989, 0096; Olsen and Dewart 1990, 0365), and additional manuals and sample-processing procedures (Lopez 1990, 0348).

5.5.1 Precipitation

A continuous record of the precipitation at the EETF (for the ITP demonstration, the protective barrier landfill cover plots, and the natural piñon/juniper transect) is maintained using a tipping bucket rain gauge (with a heater and wind screen to measure precipitation as snowfall) and a long-term-event recorder to measure between the two central ITP plots, which are located between the two central plots. The event recorder and battery power source are housed in a data acquisition trailer. An additional backup system is included in the protective barrier landfill cover plots study described in Section 5.1.1.1. In addition, a meteorological station was established at TA-69 in 1992.

The Air Quality and Meteorology Section of the Laboratory's Environmental Protection Group (EM-8) maintains a meteorological tower at MDA G (Olsen and Dewart 1990, 0365), which is currently used to back up the precipitation gauge at the EETF. In addition to precipitation data, data that will be helpful in hydrologic modeling will be collected at this tower: solar radiation, temperature, wind velocity, relative humidity, and vertical wind velocity. This tower was decommissioned in 1991 and another tower was installed about 2 mi east of the disposal area.

A meteorological tower was removed from TA-50 in April 1989 and was reinstalled at TA-6 only about 2,000 ft east of MDA F (Olsen and Dewart 1990, 0365). In addition to precipitation, several parameters will be measured: wind speed, temperature, solar radiation, relative humidity, vertical wind speed, soil temperature, soil heat flux, dew point, and sensible and latent heat flux.

5.5.2 Seepage and Interflow

When seepage occurs in the ITP demonstration plots, the flow rate is determined using a graduate cylinder and a stopwatch several times a day. The total volume of leachate is collected to cross-check the estimates based on flow rate extrapolated over time. This system will be upgraded to include a tipping bucket event recorder (for each of the four field plots) attached to a data acquisition system.

The pilot studies of protective barrier performance at the EETF and the proposed pilot demonstration tests at MDAs G and F will all involve collecting interflow and leachate from several subsurface locations along the length of the barrier in each plot. This seepage will be collected in a series of large metal pans located at the bottom of the landfill profile being tested and will then flow through underground plumbing and a water flow measurement system connected to a data acquisition system. Interflow will be measured using the same technique, and total flow per sampling period will also be determined in some field installations by collecting and measuring all of the water after it flows through the water flow measurement system. The interflow collection methodology for the natural water balance studies is described in Section 5.2.

5.5.3 Run-Off

Run-off will be determined on the pilot studies of protective barrier performance (at the EETF and on the proposed pilot demonstrations at MDAs G and F). Run-off from the surface area of each field plot will be collected and measured by techniques similar to those used for determining seepage and interflow. The run-off collection system used for the natural areas is described in Section 5.2.

If the funding levels for the pilot studies permit, the concentration of soil in each run-off event will be determined by mixing a representative fraction of each run-off event and determining the sediment concentration gravimetrically. The soil loss rate can then be determined for each run-off event.

5.5.4 Change in Storage of Soil Water

Storage of soil water will be determined using neutron moisture gauges and TDR. The neutron moisture gauge readings will be collected once a week at sampling locations throughout each profile at increments of 8 in. Neutron moisture gauge access tubes will be emplaced at a sampling density of about 1 per 55 ft^2 of field plot area.

TDR will be used when the neutron moisture gauge cannot provide an adequate estimate of soil water content. This procedure consists of inserting 6-,12-, and 24-in. waveguides in the soil layers to be monitored and measuring soil water content on a schedule varying from three times a day (protective barrier plots) to once a week. The technique requires that measurements be taken several times a day at a sampling density of up to one assay per square meter at both the EETF and at the location of the protective barrier performance studies.

5.5.5 Evapotranspiration

On field plots instrumented for leachate collection, all of the parameters in the water balance equation, except evapotranspiration, will have been directly determined. Thus, the sampling frequency and density are similar to those for measuring changes in soil water storage. Transpiration will also be measured on vegetated sites using physiological techniques on selected trees or bushes that are representative of the entire community. Using the data on stomatal response to changing environmental variables, plus the data on tree density and size, the investigators will be able to model total community transpiration rates throughout the yearly cycle.

5.5.6 Surface Characterization

Quantification of vegetative and soil surface properties on vegetated test plots and natural area plots is critical to the evaluation of both short- and long-term site stability. Current studies at MDA B have shown the importance of vegetation and soil mulches in preventing erosion and maximizing evapotranspiration. Significant changes in the surface characteristics at MDA B have been noted from year to year and have been correlated with changes in water balance components. Documenting surface dynamics, particularly over time, is thus an important task. Variables to be measured or estimated include (1) soil coverage by class of material (rock, litter, cryptogams, grass/forb crowns, perennial stem bases); (2) soil coverage by plant canopy at

different heights (grass, shrub, tree); (3) leaf area index by growth form (grass, forb, shrub, tree) and/or species (shrubs and trees); (4) vegetative biomass by growth form and species; and (5) microtopography of soil surface. These variables will be measured frequently (every 2 months) at selected sites until seasonal dynamics have been established. After that, annual or biannual measurements will suffice.

Photographic or high-resolution still-video documentation will primarily be used in combination with computer-assisted quantitative analysis. The Laboratory sponsored a postdoctoral fellow (Dr. Paul Rich) in 1987 and 1988 to develop this area of measurement technology. Laboratory collaborators at the University of New Mexico are also experts in this field. This methodology, backed up by periodic calibration exercises that use harvesting or point measurement techniques, is the most reliable and affords the best documentation for the purposes of QA/QC.

6.0 SITE OPERATIONS AND QUALITY ASSURANCE

An updated detailed procedures (DP) manual for site operations and QA of data is being prepared. This manual consists of detailed standardized procedures that are applicable to all pilot study field sites, followed by specific procedures for each site. A detailed manual for the MDA B pilot study has been prepared. This document will serve as the model for the DP/QA manual for all pilot studies. All QA procedures will be consistent with those specified by the ER Quality Program (Annex II).

It is intended that the manual be an ongoing record of DP and QA guidelines and that it be kept current and used by project personnel. A preliminary draft of the contents of the manual is given in Table D-1. It includes health and safety guidelines, support services, narrative descriptions of field and data management procedures, and extensive appendices of checklists that can be copied and taken to the field to guide operations.

7.0 DATA MANAGEMENT AND REDUCTION

Most of the testing procedures discussed in the previous section have already been well documented; the Environmental Science Group (EES-15) has been performing similar field tests since 1979. A manual for data management procedures was completed in FY93 to document the standard methods for managing and storing data in the pilot studies. Together, the procedures manual for data management and the site operations and QA manual described in Section 6 will provide the information needed for QA/QC.

8.0 FINAL DATA ANALYSIS AND INTERPRETATION AND EVALUATION OF TECHNOLOGY

The neutron moisture gauge data will be used along with measurements of run-off, leachate, interflow, and precipitation to estimate evapotranspiration by difference and to calculate water budgets for each plot.

The most practical comparison between the two ITP types of landfill cover designs for a semiarid region for the purpose of determining their usefulness to the operator of the waste site should be the overall comparison of the performance of the hydrologic parameters of the water balance over the 3-year duration of the experi-

ment. In the early stages of this field study, the improved plots showed an increase in evapotranspiration over that of the control plots, both because the capillary barriers retarded vertical water movement and because of the greater biomass on the improved plots (Nyhan 1990, 0155). The control plots lost about 88% of the precipitation received through evapotranspiration, whereas, at the improved plots, evapotranspiration removed about 96% of the precipitation from the landfill cover. This type of information is typical of what will be determined for the field demonstrations adjacent to the disposal areas and the natural vegetation plots.

TABLE D-1

DRAFT TABLE OF CONTENTS FOR SITE OPERATIONS DETAILED PROCEDURES AND QUALITY ASSURANCE MANUAL FOR PILOT STUDIES PROGRAM

1.0 GENERAL OVERVIEW

- 1.1 Data Quality Objectives
- 1.2 Applicable Documents
- 1.3 General Field Operations

2.0 EMERGENCY PROCEDURES

3.0 HEALTH AND SAFETY TRAINING

4.0 FIELD EXCAVATION PROCEDURES

5.0 SUPPORT SERVICES

6.0 FIELD INVESTIGATIONS

- 6.1 Field Team Personnel and Responsibilities
- 6.2 Field Data Notebooks

7.0 WATER BALANCE

- 7.1 Schedule for Data Collection
- 7.2 Collection of Run-Off and Sediments
- 7.3 Processing Sediment Samples
- 7.4 Soil Moisture Measurements
- 7.5 Site Meteorology
- 7.6 Winterization Procedures

8.0 SURFACE CHARACTERIZATION

- 8.1 Canopy Structure
- 8.2 Ground Cover
- 8.3 Surface Photogammetry
- 8.4 Tracer Studies
- 8.5 Evapotranspiration

9.0 COMPUTER FILE MANAGEMENT

- 9.1 General Procedures
- 9.2 Statistical Programs

In the protective barrier landfill cover plots installed at the EETF, various slopes, slope lengths, and hydraulic properties of soil are being varied to quantify their influence on reducing seepage and enhancing interflow. Thus, one measure of the overall efficiency of the landfill cover designs is simply differences in the amounts of leachate that penetrate the cover. In the ITP study, for example, the capillary barrier in the improved design has the potential for greatly reducing seepage in a typical year and for reducing by over half the time during which seepage is produced in an extremely wet year. The seepage can be reduced further if the surface of the improved design has a slope of 5% to 10%, as in the case of the new protective barrier landfill cover plots installed in FY92 (compared with the 0.5% slope at the surface of the ITP improved plot design), which will result in increased run-off and decreased infiltration of precipitation into the landfill cover (Equation 1).

The data to be collected in the pilot field tests will initially be used to calibrate a simple, one-dimensional model (CREAMS) in the field without extensive input parameters (Nyhan 1990, 0155). This study will produce for the first time (with the exception of the preliminary calibration on the ITP plots, which was performed with only 3 years of field data) direct measurements of all of the water balance components, making it possible to compare the measurements with model-simulated values instead of merely comparing the observed and predicted values of soil water content to evaluate the success of the hydrologic simulation. Ultimately, investigators will validate a multidimensional finite element model that uses data collected in field studies such as the ITP plots, the protective barrier landfill cover plots, and the natural systems plots to predict variations in soils, vegetation, and climate. Such models can be used to optimize the design of landfill covers at specific sites. CREAMS can also be used to design landfill covers based on 20- to 50-year projections of meteorological conditions that encompass average and record wet years so that the effectiveness of the cover designs can be assessed. The cost effectiveness and practicality of various designs will be evaluated with the help of the site operator, who will have a major influence on the selection of a final closure design for low-level radioactive and hazardous waste sites.

9.0 HEALTH AND SAFETY

Each employee is required to obtain the new-employee safety orientation and hazardous communication training offered by the Laboratory. In addition, all employees must adhere to the Environmental Science Group's (EES-15) safety requirements. These requirements include demonstrating an understanding of all standard operating procedures, emergency plans, and field safety plans. All activities will comply with requirements of the ER Program's Health and Safety Program Plan (Annex III).

10.0 MANAGEMENT OF RESIDUALS

No waste materials will be generated as a result of pilot demonstrations or testing. No simulated wastes or chemicals will be used because all the tests and demonstrations described in this appendix deal with the status of soil and plant water as a function of time.

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■ APPENDIX E

Geochemical Studies of Soils and Bandelier Tuff

GEOCHEMICAL STUDIES OF SOILS AND BANDELIER TUFF

Many of the contaminants present at Los Alamos, especially organic and actinide contaminants, do not occur naturally. When such manmade compounds as plutonium, neptunium, and americium, are found at the Laboratory, they are the result either of Laboratory operations or of global fallout from atmospheric nuclear tests. However, uranium, thorium, and most of the toxic metals listed under the Resource Conservation and Recovery Act (RCRA) occur naturally in the soils and rocks exposed in the Los Alamos area and in the sediments of the Santa Fe Group that make up the main aquifer below. In order to determine whether contamination by these elements exists, it is necessary to know their natural concentrations in a sample.

The purpose of this investigation is to determine the range of background concentrations of important contaminants such as barium, beryllium, chromium, lead, and uranium in several soil series and sediments and in the Bandelier Tuff at Los Alamos National Laboratory (the Laboratory). Neutron activation analysis is used to determine the background levels of 43 elements. These analyses are supplemented as necessary (e.g., in the cases of beryllium and lead) by other analytical techniques. Evaluation of these elemental concentrations is needed to establish the extent of soil, sediment, and bedrock contamination at different operable units.

The media most susceptible to contamination are soils (Nyhan et al. 1978, 0161) and the Bandelier Tuff (Griggs and Hem 1964, 0313), which are exposed over most of the area affected by Laboratory operations. Ferenbaugh et al. (1990, 0099) present analyses for soil from Sigma Mesa, and Crowe et al. (1979, 0041) and (Kuentz 1986, 0602) give analyses for the Bandelier Tuff. None of these studies, however, covers the complete range of elements of interest. There are few data on the chemical variability of the soils (which is controlled by pedogenesis), chemical compositions of parent materials, and mineralogy, and there are only limited data on the variability of the tuff.

Nyhan et al. (1978, 0161) identified 56 soil series in Los Alamos County. In order to develop a chemical background model for soils, it is necessary to assess the chemical variability of these soil series. Each soil consists of several soil horizons that show different physical properties and that are chemically distinct. The soils have the potential to be rather highly chemically variable because of their varying content of clay minerals, ferric oxyhydroxides, humic acids, silicate minerals, carbonate minerals, and silica-rich glass. If there are variations in the soil series, then a significant portion of the variation is present at each sample location.

The Bandelier Tuff is made up of an upper (Tschirege) and lower (Otowi) member. Each member consists of an airfall tuff at the base, followed by ash flows. The ash flows of the lower member have not been subdivided, but Crowe et al. (1978, 0041) recognize three cooling units within the ash flows of the upper member. More recently, Vaniman and Wohletz (1990, 0541) separated the upper member of the Bandelier Tuff into four cooling units. A cooling unit is thought to represent a series of flows that erupted close enough together that they cooled as a single unit. These units appear to provide a useful basis upon which to build a background geochemical model for the Bandelier Tuff.

The uranium concentrations in the airfall of the lower member range from 14.0 to 17.8 ppm, averaging 16.9 ppm, although, omitting Sample 18/12, values for the lower

member ashfalls range from 4.9 to 17.6 ppm and average 10.0 ppm (Kuentz 1986, 0602). In the upper member, uranium concentrations range from 6.86 to 11.35 ppm in Cooling Unit 1 (excluding Sample 4250.1) and average 8.8 ppm. In Cooling Unit 2, the uranium concentrations range from 4.0 to 4.9 ppm (Crowe et al. 1978, 0041). The data set for the ash flows of the lower member is the only one in which samples were obtained from several locations. The large range of uranium concentrations in this unit, however, is not caused solely by lateral compositional variations within the unit. A significant portion of the variation is present at each sample location.

All the tuff samples obtained to date have been taken from the surface, and therefore some of the variation in uranium content may be the result of surface alteration because uranium can be quite mobile in the oxidizing environment found at the surface. This source of variability, however, appears to be minor. The thorium-to-uranium ratios are relatively constant within cooling units and vary only slightly more among units. The immobility of thorium suggests that there has been little uranium migration. The exceptions are Samples 4250.1 and 18/21. Both these samples have lower uranium concentrations than the other samples in the cooling unit from which they come and also have high thorium-to-uranium ratios, which suggests that uranium has been leached from these samples.

In order to develop background geochemical models, the investigators will examine the sources of chemical variability. This variability may arise during the formation of the soils and Bandelier Tuff or as the result of subsequent alteration. In particular, the investigators will examine vertical and lateral variation and the effects of surface alteration. Even if identifiable and mappable units, such as cooling units, are rather variable with respect to concentrations of individual elements, it will probably be possible to identify less variable quantities, such as element ratios that can be used to identify anomalous samples. Although a high thorium-to-uranium ratio does not enable the investigator to distinguish between thorium contamination and uranium depletion, other ratios, such as that of niobium to uranium (which is observed to be quite constant in the lower member of the Bandelier Tuff), could be used to more definitively assess possible contamination. The elements of primary interest are uranium, thorium, and the RCRA toxic metals, but the investigators will also analyze for other elements, which, like niobium, are not of regulatory concern but may help predict the natural abundance of other metals.

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■ APPENDIX F

Potential Release Sites at Los Alamos National Laboratory

Codes and Abbreviations Used

PRS Class Codes

'88 SWMU'	A PRS first listed in the 1988 SWMU report but not listed in the HSWA Module.
'A SWMU'	A PRS listed in Table A of the HSWA Module.
'B SWMU'	A PRS listed in Table A & B of the HSWA Module.
'90 SWMU'	A PRS first listed in the 1990 SWMU report.
'IWP SWMU'	A PRS first listed in the 1990 IWP.
'RFI SWMU'	A PRS first listed in the RFI work plan for its OU.
'91 SWMU'	A PRS first listed in the 1991 IWP revision.
'9# SWMU'	A PRS added since the 1991 IWP revision (The '#' should be replaced by the year of addition.).
'AOC'	Any PRS that is not a SWMU.

Potential Contaminant Abbreviations

'RAD'	Possible radioactive waste.
'HE'	Possible high explosives.
'ORG'	Possible organic materials.
'INORG'	Possible inorganic materials.
'METALS'	Possible metals
'SOLV'	Possible solvents.
'PHOCHEM'	Possible photochemicals.
'PCB'	Possible polychlorinated biphenyls.
'PET'	Possible petroleum products.
'CAUST'	Possible caustics.
'BIOCIDES'	Possible biocides.
'HERBICIDES'	Possible herbicides.
'ASBESTOS'	Possible asbestos.

Potential Remedial Action Codes

'CARBC;IC'	Clean to acceptable risk-based criteria;institutional controls
'IS;IC'	In-place stabilization; institutional controls
'rec NFA'	Recommended to the administrative authority for no further action
'NFA'	No further action

PRS Information for OU # 1049

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
0-001	0.	A SWMU	Surface impoundments	Active	8418	RAD, ORG, INORG, METALS	CARBC;IC
C-0-001	0	AOC	Canyon		278000	HE, ORG, INORG, METALS	CARBC;IC
C-0-002	0	AOC	Canyon		31500	HE, ORG, INORG, METALS	CARBC;IC
C-0-003	0	AOC	Canyon		48900	HE, ORG, INORG, METALS	CARBC;IC
C-0-004	0	AOC	Canyon		685240	RAD, ORG, INORG, METALS	CARBC;IC
C-0-005	0	AOC	Canyon		703760	RAD, ORG, INORG, METALS	CARBC;IC
C-0-006	0	AOC	Canyon		1148240	RAD, ORG, INORG, METALS	CARBC;IC
C-0-007	0	AOC	Canyon		533376	RAD, ORG, INORG, METALS	CARBC;IC
C-0-008	0	AOC	Canyon		870440	RAD, ORG, INORG, METALS	CARBC;IC
C-0-009	0	AOC	Canyon		704000	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-0-010	0	AOC	Canyon		207424	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-0-011	0	AOC	Canyon		1074160	RAD, ORG, INORG, METALS	CARBC;IC
C-0-012	0	AOC	Canyon		107000	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-0-013	0	AOC	Canyon		629680	RAD, ORG, INORG, METALS	CARBC;IC
C-0-014	0	AOC	Canyon		333000	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-0-015	0	AOC	Canyon		194000	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1049

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-0-016	0	AOC	Canyon		1185280	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-0-017	0	AOC	Canyon		342000	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-0-018	0	AOC	Canyon		296000	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-0-019	0	AOC	Canyon		185000	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1071

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
0-003	0	A SWMU	Container storage	Decommission	2	ORG, INORG, METALS	CARBC;IC
0-004	0	88 SWMU	Container storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
0-005	0	B SWMU	Landfill	Inactive	15	RAD, ORG, INORG, METALS	rec NFA
0-008	0	88 SWMU	Surface disposal	Inactive	17	ORG, INORG, METALS	rec NFA
0-010(a)	0	90 SWMU	Surface disposal	Inactive	4034	ORG, INORG, METALS	rec NFA
0-010(b)	0	91 SWMU	Surface disposal	Decommission	315	ORG, INORG, METALS	rec NFA
0-011(a)	0	88 SWMU	Mortar impact area	Inactive	2020	HE, ORG, INORG, METALS	CARBC;IC
0-011(c)	0	88 SWMU	Mortar impact area	Inactive	2020	HE, ORG, INORG, METALS	CARBC;IC
0-011(d)	0	88 SWMU	Mortar impact area	Inactive	2020	HE, ORG, INORG, METALS	CARBC;IC
0-011(e)	0	88 SWMU	Mortar impact area	Inactive	2020	HE, ORG, INORG, METALS	CARBC;IC
0-012	0	A SWMU	Underground tank	Active	5	ORG, INORG, METALS, BIOCIDES	CARBC;IC
0-015	0	88 SWMU	Firing range	Active	405	ORG, INORG, METALS	rec NFA
0-016	0	88 SWMU	Firing range	Inactive	808	ORG, INORG, METALS	CARBC;IC
0-017	0	A SWMU	Waste lines	Inactive	283	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
0-018(a)	0	88 SWMU	Waste water treatment facility	Active	2814	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
0-018(b)	0	88 SWMU	Waste water treatment facility	Active	2926	RAD, ORG, INORG, METALS, SOLV	CARBC;IC

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PRS Information for OU # 1071

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
0-019	0	88 SWMU	Waste water treatment facility	Decommission	1676	RAD, ORG, INORG, METALS	CARBC;IC
0-024	0	90 SWMU	Holding site	Inactive	5	ORG, INORG, METALS	rec NFA
0-025	0	90 SWMU	Landfill	Inactive	116	ORG, INORG, METALS	rec NFA
0-026	0	90 SWMU	Landfill	Inactive	21	RAD, ORG, INORG, METALS	rec NFA
0-027	0	90 SWMU	Storage area	Inactive	966	ORG, INORG, METALS, PET	CARBC;IC
0-028(a)	0	90 SWMU	Effluent discharge	Inactive	56550	RAD, ORG, INORG, METALS	CARBC;IC
0-028(b)	0	90 SWMU	Effluent discharge	Inactive	37700	RAD, ORG, INORG, METALS	CARBC;IC
0-029(a)	0	90 SWMU	Transformer	Decommission	1	ORG, INORG, METALS, PCB	CARBC;IC
0-029(b)	0	90 SWMU	Transformer	Decommission	1	ORG, INORG, METALS, PCB	CARBC;IC
0-029(c)	0	90 SWMU	Transformer	Decommission	1	ORG, INORG, METALS, PCB	CARBC;IC
0-030(a)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(b)	0	90 SWMU	Septic system	Unknown	56	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(c)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(d)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(e)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(f)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC

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PRS Information for OU # 1071

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
0-030(g)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(h)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(i)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(j)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(k)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(l)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(m)	0	90 SWMU	Septic system	Unknown	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(n)	0	91 SWMU	Septic system	Inactive	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(o)	0	91 SWMU	Septic system	Inactive	5	ORG, INORG, METLAS, SOLV	CARBC;IC
0-030(p)	0	91 SWMU	Septic system	Inactive	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-030(q)	0	91 SWMU	Septic system	Inactive	5	ORG, INORG, METALS, SOLV	CARBC;IC
0-031(a)	0	90 SWMU	Underground distribution tanks	Removed	230	ORG, INORG, METALS, PET	CARBC;IC
0-031(b)	0	90 SWMU	Underground distribution tank	Removed	230	ORG, INORG, METALS, PET	CARBC;IC
0-032	0	90 SWMU	Operational facility	Inactive	2918	ORG, INORG, METALS	CARBC;IC
0-033	0	90 SWMU	Warehouses	Inactive	1043	ORG, INORG, METALS, SOLV, PET	CARBC;IC
0-034(a)	0	91 SWMU	Landfill	Inactive	394	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1071

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
0-034(b)	0	91 SWMU	Landfill	Inactive	473	ORG, INORG, METALS	CARBC;IC
0-035(a)	0	91 SWMU	Surface disposal	Inactive	1	PET	rec NFA
C-0-020	0	AOC	Mortar impact area	Inactive	0		CARBC;IC
19-001	19	A SWMU	Septic system	Inactive	4	ORG, INORG, METALS, SOLV	CARBC;IC
19-002	19	88 SWMU	Surface disposal	Inactive	74	ORG, INORG, METALS	CARBC;IC
19-003	19	90 SWMU	Drain line and outfall	Inactive	1	ORG, INORG, METALS, SOLV	CARBC;IC
C-19-001	19	AOC	Buildings	Removed	2222	RAD, ORG, INORG, METALS	CARBC;IC
26-001	26	88 SWMU	Surface disposal	Inactive	111	RAD, ORG, INORG, METALS	CARBC;IC
26-002(a)	26	88 SWMU	Sump	Decommission	5	RAD, ORG, INORG, METALS	CARBC;IC
26-002(b)	26	90 SWMU	Outfall	Decommission	1	RAD, ORG, INORG, METALS	CARBC;IC
26-003	26	88 SWMU	Septic system	Decommission	9	RAD, ORG, INORG, METALS	CARBC;IC
73-001(a)	73	B SWMU	Landfill	Inactive	1070	RAD, HE, ORG, INORG, METALS, PCB	CARBC;IC
73-001(b)	73	B SWMU	Disposal pit	Inactive	4	ORG, INORG, METALS, PET	CARBC;IC
73-001(c)	73	90 SWMU	Surface disposal	Inactive	171	HE, ORG, INORG, METALS	CARBC;IC
73-001(d)	73	90 SWMU	Disposal pits	Inactive	4	ORG, INORG, METALS	CARBC;IC
73-002	73	A SWMU	Incinerator and surface disposal	Inactive	2019	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1071

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
73-003	73	88 SWMU	Operational facility	Decommission	8	ORG, INORG, METALS, SOLV	CARBC;IC
73-004(a)	73	88 SWMU	Septic system	Inactive	22	ORG, INORG, METALS, SOLV	CARBC;IC
73-004(b)	73	88 SWMU	Septic system	Inactive	11	ORG, INORG, METALS, SOLV	CARBC;IC
73-004(c)	73	90 SWMU	Septic system	Inactive	22	ORG, INORG, METALS, SOLV	CARBC;IC
73-004(d)	73	90 SWMU	Septic system	Inactive	22	ORG, INORG, METALS, SOLV	CARBC;IC
73-005	73	88 SWMU	Surface disposal	Inactive	750	ORG, INORG, METALS	CARBC;IC
73-006	73	90 SWMU	Outfalls	Inactive	926	HE, ORG, INORG, METALS	CARBC;IC
C-73-001	73	AOC	Underground tank	Active	0		rec NFA
C-73-002	73	AOC	Underground tank	Active	0		rec NFA
C-73-003	73	AOC	Underground tank	Acctive	0		rec NFA
C-73-004	73	AOC	Underground tank	Active	0		rec NFA

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PRS Information for OU # 1078

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
1-001(a)	1	B SWMU	Septic system	Inactive	13	RAD, ORG, INORG, METALS	CARBC;IC
1-001(b)	1	B SWMU	Septic system	Inactive	8	RAD, ORG, INORG, METALS	rec NFA
1-001(c)	1	B SWMU	Septic system	Inactive	4	RAD, ORG, INORG, METALS	CARBC;IC
1-001(d)	1	B SWMU	Septic system	Inactive	4	RAD, ORG, INORG, METALS	CARBC;IC
1-001(e)	1	B SWMU	Septic system	Inactive	6	RAD, ORG, INORG, METALS	CARBC;IC
1-001(f)	1	B SWMU	Septic system	Inactive	18	RAD, ORG, INORG, METALS	CARBC;IC
1-001(g)	1	B SWMU	Septic system	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
1-001(h)	1	B SWMU	Septic system	Inactive	11	ORG, INORG, METALS	rec NFA
1-001(i)	1	B SWMU	Septic system	Inactive	3	RAD, ORG, INORG, METALS	CARBC;IC
1-001(j)	1	B SWMU	Septic system	Inactive	2	ORG, INORG, METALS	rec NFA
1-001(k)	1	B SWMU	Septic system	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
1-001(l)	1	B SWMU	Septic system	Inactive	2	RAD, ORG, INORG, METALS	rec NFA
1-001(m)	1	B SWMU	Septic system	Inactive	2	ORG, INORG, METALS	rec NFA
1-001(n)	1	B SWMU	Septic system	Inactive	5	RAD, ORG, INORG, METALS	CARBC;IC
1-001(o)	1	90 SWMU	Septic system	Inactive	3	RAD, ORG, INORG, METALS	CARBC;IC
1-001(p)	1	90 SWMU	Septic system	Inactive	5	RAD, ORG, INORG, METALS	rec NFA

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PRS Information for OU # 1078

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
1-001(q)	1	90 SWMU	Septic system	Inactive	5	ORG, INORG, METALS	rec NFA
1-001(r)	1	90 SWMU	Septic system	Inactive	4	ORG, INORG, METALS	rec NFA
1-001(s)	1	90 SWMU	Septic system	Inactive	29	RAD, ORG, INORG, METALS	CARBC;IC
1-001(t)	1	90 SWMU	Septic system	Inactive	24	RAD, ORG, INORG, METALS	CARBC;IC
1-001(u)	1	90 SWMU	Septic system	Inactive	2	RAD, ORG, INORG, METALS	rec NFA
1-001(v)	1	90 SWMU	Septic system	Inactive	1	ORG, INORG, METALS	rec NFA
1-001(w)	1	90 SWMU	Septic system	Inactive	2	ORG, INORG, METALS	rec NFA
1-002	1	B SWMU	Waste lines and outfall	Decommission	24925	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
1-003(a)	1	B SWMU	Landfill	Inactive	74080	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
1-003(b)	1	90 SWMU	Surface disposal	Inactive	926	RAD, ORG, INORG, METALS	rec NFA
1-003(c)	1	90 SWMU	Surface disposal	Inactive	926	RAD, ORG, INORG, METALS	rec NFA
1-003(d)	1	90 SWMU	Surface disposal	Inactive	926	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
1-003(e)	1	90 SWMU	Surface disposal	Inactive	926	RAD, ORG, INORG, METALS	CARBC;IC
1-004(a)	1	88 SWMU	Incinerator	Decommission	37	ORG, INORG, METALS	rec NFA
1-004(b)	1	88 SWMU	Incinerator	Decommission	37	ORG, INORG, METALS	rec NFA
1-005	1	88 SWMU	Incinerator	Decommission	4	RAD, ORG, INORG, METALS	rec NFA

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PRS Information for OU # 1078

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
1-006(a)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(b)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(c)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(d)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(e)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(f)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	rec NFA
1-006(g)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(h)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(i)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	rec NFA
1-006(j)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	rec NFA
1-006(k)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(l)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(m)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(n)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(o)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(p)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1078

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
1-006(q)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	rec NFA
1-006(r)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-006(s)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	rec NFA
1-006(t)	1	90 SWMU	Drain lines and outfall	Inactive	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(a)	1	90 SWMU	Building	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(b)	1	90 SWMU	Building	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(c)	1	RFI SWMU	Building	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(d)	1	RFI SWMU	Buildings	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(e)	1	RFI SWMU	Building	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(f)	1	RFI SWMU	Building	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(g)	1	RFI SWMU	Warehouse	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(h)	1	RFI SWMU	Buildings	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(i)	1	RFI SWMU	Warehouses	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(j)	1	RFI SWMU	Buildings	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(k)	1	RFI SWMU	Buildings	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(l)	1	RFI SWMU	Building	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1078

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
1-007(m)	1	RFI SWMU	Building	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(o)	1	RFI SWMU	Building	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC
1-007(p)	1	RFI SWMU	Building	Decommission	0	RAD, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-016(c)	3	88 SWMU	Septic system	Active	2	ORG, INORG, METALS	CARBC;IC
3-016(d)	3	90 SWMU	Septic system	Active	7	ORG, INORG, METALS	CARBC;IC
3-016(e)	3	90 SWMU	Septic system	Active	7	ORG, INORG, METALS	CARBC;IC
3-018	3	A SWMU	Septic system	Inactive	4	ORG, INORG, METALS	CARBC;IC
3-019	3	88 SWMU	Septic system	Decommission	7	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
3-020(a)	3	B SWMU	Disposal pit	Inactive	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-020(b)	3	90 SWMU	Disposal pit	Active	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-021	3	88 SWMU	Sump	Inactive/d	139	ORG, INORG, METALS	CARBC;IC
3-022	3	88 SWMU	Sump	Active	198	ORG, INORG, METALS, PET	CARBC;IC
3-023	3	88 SWMU	Sump	Inactive	2	ORG, INORG, METALS, PET	CARBC;IC
3-024	3	88 SWMU	Sump	Active	118	ORG, INORG, METALS	CARBC;IC
3-025(a)	3	88 SWMU	Sump	Active	10	ORG, INORG, METALS, PET	CARBC;IC
3-025(b)	3	88 SWMU	Sump	Active	7	RAD, ORG, INORG, METALS, PET	CARBC;IC
3-025(c)	3	90 SWMU	Sump	Active	10	ORG, INORG, METALS, PET	CARBC;IC
3-026(a)	3	88 SWMU	Sump	Active	22	ORG, INORG, METALS	CARBC;IC
3-026(b)	3	90 SWMU	Sump	Active	8	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1114

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-026(c)	3	90 SWMU	Sump	Active	12	ORG, INORG, METALS	CARBC;IC
3-026(d)	3	90 SWMU	Sump	Active	1	ORG, INORG, METALS	CARBC;IC
3-027	3	88 SWMU	Separation site	Active	2	ORG, INORG, METALS, PET	CARBC;IC
3-028	3	A SWMU	Surface impoundment	Active	4	ORG, INORG, METALS	CARBC;IC
3-029	3	B SWMU	Landfill	Inactive	11850	ORG, INORG, METALS, PET	CARBC;IC
3-030	3	88 SWMU	Surface impoundment	Inactive	990	ORG, INORG, METALS, FLOURIDE	CARBC;IC
3-031	3	88 SWMU	Sump	Active	104	RAD, HE, ORG, INORG, METALS	CARBC;IC
3-032	3	88 SWMU	Aboveground tank	Inactive	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-033	3	A SWMU	Sump	Active	1	ORG, INORG, METALS, ACIDS	CARBC;IC
3-034(a)	3	88 SWMU	Underground tank	Standby	1	RAD, ORG, INORG, METALS	CARBC;IC
3-034(b)	3	90 SWMU	Underground tank	Active	1	RAD, ORG, INORG, METALS	CARBC;IC
3-035(a)	3	A SWMU	Underground tank	Active	50	ORG, INORG, METALS, PET	CARBC;IC
3-035(b)	3	A SWMU	Underground tank	Active	15	ORG, INORG, METALS, PET	CARBC;IC
3-036(a)	3	A SWMU	Aboveground tanks	Active	21	ORG, INORG, METALS	CARBC;IC
3-036(b)	3	88 SWMU	Aboveground tanks	Active	0	ORG, INORG, METALS, PET	CARBC;IC
3-036(c)	3	A SWMU	Aboveground tanks	Active	0	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-036(d)	3	A SWMU	Aboveground tanks	Active	0	ORG, INORG, METALS	CARBC;IC
3-036(e)	3	A SWMU	Aboveground tank	Inactive	25	ORG, INORG, METALS	CARBC;IC
3-036(f)	3	90 SWMU	Aboveground tank	Active	1	ORG, INORG, METALS, PET	CARBC;IC
3-036(g)	3	90 SWMU	Aboveground tank	Active	3	ORG, INORG, METALS, PET	CARBC;IC
3-036(h)	3	90 SWMU	Aboveground tank	Active	20	ORG, INORG, METALS, ACIDS	CARBC;IC
3-036(i)	3	90 SWMU	Aboveground tank	Active	40	ORG, INORG, METALS	CARBC;IC
3-036(j)	3	90 SWMU	Aboveground tanks	Active	1	ORG, INORG, METALS, PET	CARBC;IC
3-037(a)	3	A SWMU	Underground tank	Inactive	25	ORG, INORG, METALS, ACIDS	CARBC;IC
3-038(a)	3	A SWMU	Waste lines	Decommission	23	ORG, INORG, METALS, ACIDS	CARBC;IC
3-038(b)	3	A SWMU	Tank	Decommission	82	ORG, INORG, METALS, ACIDS	CARBC;IC
3-038(c)	3	90 SWMU	Waste lines	Decommission	1	ORG, INORG, METALS, ACIDS	CARBC;IC
3-038(d)	3	90 SWMU	Waste lines	Inactive	12	ORG, INORG, METALS	CARBC;IC
3-038(e)	3	90 SWMU	Waste lines	Inactive	12	ORG, INORG, METALS	CARBC;IC
3-038(f)	3	90 SWMU	Waste lines	Inactive	20	ORG, INORG, METALS	CARBC;IC
3-039(a)	3	A SWMU	Silver recovery unit	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
3-039(b)	3	A SWMU	Silver recovery unit	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-039(c)	3	A SWMU	Silver recovery unit	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
3-039(d)	3	A SWMU	Silver recovery unit	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
3-039(e)	3	A SWMU	Silver recovery unit	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
3-040(a)	3	88 SWMU	Storage area	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
3-040(b)	3	88 SWMU	Storage area	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
3-041	3	88 SWMU	Underground tank	Active	6	RAD, ORG, INORG, METALS	CARBC;IC
3-042	3	88 SWMU	Sump	Decommission	1	ORG, INORG, METALS, PET	CARBC;IC
3-043(a)	3	90 SWMU	Aboveground tank	Decommission	99	ORG, INORG, METALS	CARBC;IC
3-043(c)	3	88 SWMU	Aboveground tank	Decommission	99	ORG, INORG, METALS	CARBC;IC
3-043(d)	3	90 SWMU	Aboveground tank	Decommission	99	ORG, INORG, METALS	CARBC;IC
3-043(e)	3	A SWMU	Aboveground tank	Decommission	99	ORG, INORG, METALS, PET	CARBC;IC
3-043(f)	3	90 SWMU	Aboveground tank	Decommission	50	ORG, INORG, METALS, PET	CARBC;IC
3-043(g)	3	90 SWMU	Aboveground tank	Decommission	149	ORG, INORG, METALS	CARBC;IC
3-043(h)	3	90 SWMU	Aboveground tank	Decommission	50	ORG, INORG, METALS, PET	CARBC;IC
3-043(i)	3	90 SWMU	Aboveground tank	Decommission	99	ORG, INORG, METALS	CARBC;IC
3-044(a)	3	A SWMU	Container storage	Decommission	5	ORG, INORG, METALS	CARBS;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-044(b)	3	90 SWMU	Container storage	Decommission	5	ORG, INORG, METALS	CARBC;IC
3-045(a)	3	88 SWMU	Outfall	Active	1833	ORG, INORG, METALS	CARBC;IC
3-045(b)	3	90 SWMU	Outfall	Active	1833	ORG, INORG, METALS	CARBC;IC
3-045(c)	3	90 SWMU	Outfall	Active	5236	ORG, INORG, METALS	CARBC;IC
3-045(d)	3	90 SWMU	Outfall	Active	5341	ORG, INORG, METALS	CARBC;IC
3-045(e)	3	90 SWMU	Outfall	Active	1257	ORG, INORG, METALS	CARBC;IC
3-045(f)	3	90 SWMU	Outfall	Active	52	ORG, INORG, METALS	CARBC;IC
3-045(g)	3	90 SWMU	Outfall	Active	314	ORG, INORG, METALS	CARBC;IC
3-045(h)	3	90 SWMU	Outfall	Active	236	ORG, INORG, METALS	CARBC;IC
3-045(i)	3	90 SWMU	Outfall	Unknown	209	ORG, INORG, METALS	CARBC;IC
3-046	3	90 SWMU	Aboveground tank	Active	99	ORG, INORG, METALS	CARBC;IC
3-047(a)	3	90 SWMU	Storage area	Active	12	ORG, INORG, METALS, PCB	CARBC;IC
3-047(b)	3	A SWMU	Storage area	Active	82	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-047(c)	3	90 SWMU	Storage area	Active	12	ORG, INORG, METALS	CARBC;IC
3-047(d)	3	90 SWMU	Storage area	Active	6	ORG, INORG, METALS, PET	CARBC;IC
3-047(e)	3	90 SWMU	Storage area	Active	6	ORG, INORG, METALS, SOLV, PET	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-047(f)	3	90 SWMU	Storage area	Active	6	RAD, ORG, INORG, METALS, PHOCHEM	CARBC;IC
3-047(g)	3	90 SWMU	Storage area	Active	23	RAD, ORG, INORG, METALS	CARBC;IC
3-047(h)	3	90 SWMU	Storage area	Active	3	ORG, INORG, METALS, PET	CARBC;IC
3-047(i)	3	90 SWMU	Storage area	Active	3	ORG, INORG, METAL, SOLV, PET	CARBC;IC
3-047(j)	3	90 SWMU	Storage area	Inactive	6	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-047(k)	3	90 SWMU	Storage area	Active	3	ORG, INORG, METALS	CARBC;IC
3-048	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
3-049(a)	3	90 SWMU	Outfall	Active	52	ORG, INORG, METALS	CARBC;IC
3-049(b)	3	90 SWMU	Outfall	Active	105	ORG, INORG, METALS, PET	CARBC;IC
3-049(c)	3	90 SWMU	Outfall	Active	28	ORG, INORG, METALS, ACIDS	CARBC;IC
3-049(d)	3	90 SWMU	Outfall	Active	26	ORG, INORG, METALS, ACIDS	CARBC;IC
3-049(e)	3	90 SWMU	Outfall	Active	26	ORG, INORG, METALS, ACIDS	CARBC;IC
3-050(a)	3	90 SWMU	Occasional release site	Active	0	RAD, ORG, INORG, METALS	CARBC;IC
3-050(b)	3	90 SWMU	Systematic leak	Active	0	ORG, INORG, METALS, TRITIUM	CARBC;IC
3-050(c)	3	90 SWMU	Occasional release site	Active	0	RAD, ORG, INORG, METALS	CARBC;IC
3-050(d)	3	90 SWMU	Systematic leak	Active	0	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-050(e)	3	90 SWMU	Filter system	Active	0	ORG, INORG, METALS	CARBC;IC
3-050(f)	3	90 SWMU	Systematic leak	Active	0	ORG, INORG, METALS	CARBC;IC
3-050(g)	3	90 SWMU	Systematic leak	Active	0	ORG, INORG, METALS	CARBC;IC
3-051(a)	3	90 SWMU	Machinery	Active	1	ORG, INORG, METALS, PET	CARBC;IC
3-051(b)	3	90 SWMU	Machinery	Active	1	ORG, INORG, METALS, PET	CARBC;IC
3-051(c)	3	90 SWMU	Machinery	Active	1	ORG, INORG, METALS, PET	CARBC;IC
3-051(d)	3	90 SWMU	Machinery	Active	1	ORG, INORG, METALS, PET	CARBC;IC
3-052(a)	3	90 SWMU	Storm drainage	Active	26	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-052(b)	3	90 SWMU	Storm drainage	Active	47	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-052(c)	3	90 SWMU	Storm drainage	Active	20	ORG, INORG, METALS, PET	CARBC;IC
3-052(d)	3	90 SWMU	Storm drainage	Active	23	ORG, INORG, METALS	CARBC;IC
3-052(e)	3	90 SWMU	Storm drainage	Active	23	ORG, INORG, METALS	CARBC;IC
3-052(f)	3	90 SWMU	Storm drainage and outfall	Active	20	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-053	3	90 SWMU	Operational facility	Active	14	RAD, ORG, INORG, METALS	CARBC;IC
3-054(a)	3	90 SWMU	Outfall	Active	105	ORG, INORG, METALS	CARBC;IC
3-054(b)	3	90 SWMU	Outfall	Active	111	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-054(c)	3	90 SWMU	Outfall	Active	41	ORG, INORG, METALS	CARBC;IC
3-054(d)	3	90 SWMU	Outfall	Active	13	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-054(e)	3	90 SWMU	Outfall	Active	2592	ORG, INORG, METALS	CARBC;IC
3-055(a)	3	90 SWMU	Outfall	Inactive	26	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
3-055(b)	3	90 SWMU	Outfall	Active	157	ORG, INORG, METALS, ACIDS	CARBC;IC
3-055(c)	3	90 SWMU	Outfall	Active	52	ORG, INORG, METALS	CARBC;IC
3-055(d)	3	90 SWMU	Outfall	Inactive	0	ORG, INORG, METALS	CARBC;IC
3-056(a)	3	A SWMU	Storage area	Active	23	ORG, INORG, METALS	CARBC;IC
3-056(b)	3	88 SWMU	Storage area	Active	12	ORG, INORG, METALS, PET	CARBC;IC
3-056(c)	3	A SWMU	Storage area	Active	3	ORG, INORG, METALS, PCB, PET	CARBC;IC
3-056(d)	3	88 SWMU	Storage area	Active	36	ORG, INORG, METALS, PET	CARBC;IC
3-056(e)	3	88 SWMU	Storage area	Active	23	ORG, INORG, METALS, PET	CARBC;IC
3-056(f)	3	88 SWMU	Storage area	Active	3	ORG, INORG, METALS, PET	CARBC;IC
3-056(g)	3	90 SWMU	Storage area	Active	6	ORG, INORG, METALS, PET	CARBC;IC
3-056(h)	3	88 SWMU	Storage area	Active	92	ORG, INORG, METALS, PET	CARBC;IC
3-056(i)	3	90 SWMU	Storage area	Unknown	46	ORG, INORG, METALS, PET	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-056(j)	3	90 SWMU	Storage area	Unknown	12	ORG, INORG, METALS, PET	CARBC;IC
3-056(k)	3	90 SWMU	Storage area	Unknown	3	RAD, ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-056(l)	3	90 SWMU	Storage area	Unknown	3	ORG, INORG, METALS	CARBC;IC
3-056(m)	3	90 SWMU	Storage area	Unknown	23	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-056(n)	3	90 SWMU	Storage area	Unknown	12	ORG, INORG, METALS	CARBC;IC
3-057	3	90 SWMU	Sump	Active	7	ORG, INORG, METALS	CARBC;IC
3-058	3	90 SWMU	Container storage	Active	0		CARBC;IC
3-059	3	90 SWMU	Storage area	Active	889	ORG, INORG, METALS, ACIDS, PET	CARBC;IC
C-3-001	3	AOC		Unknown	0		CARBC;IC
C-3-002	3	AOC	One-time spill	Inactive	0		CARBC;IC
C-3-003	3	AOC	One-time spill	Unknown	1	ORG, INORG, METALS	CARBC;IC
C-3-004	3	AOC	One-time spill	Unknown	4	ORG, INORG, METALS, PET	CARBC;IC
C-3-005	3	AOC	One-time spill	Unknown	556	ORG, INORG, METALS, PET	CARBC;IC
C-3-006	3	AOC	One-time spill	Unknown	111	RAD, ORG, INORG, METALS	CARBC;IC
C-3-007	3	AOC	Building	Inactive	0		CARBC;IC
C-3-008	3	AOC	Building	Inactive	0		CARBC;IC
C-3-009	3	AOC	Building	Active	0		CARBC;IC
C-3-010	3	AOC	Reactor facility	Removed	370	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-3-011	3	AOC	Tank	Removed	7	ORG, INORG, METALS, PET	CARBC;IC
C-3-012	3	AOC	Storage area	Active	0		CARBC;IC
C-3-014	3	AOC	Storage area	Active	93	RAD, ORG, INORG, METALS	CARBC;IC
C-3-015	3	AOC	Underground distribution tank	Active	0		CARBC;IC
C-3-016	3	AOC	Tank	Active	5	ORG, INORG, METALS, SOLV, PET	CARBC;IC
C-3-017	3	AOC	Underground distribution tank	Active	0		CARBC;IC
C-3-018	3	AOC	Underground distribution tank	Active	0		CARBC;IC
C-3-019	3	AOC	Underground tank	Active	37	ORG, INORG, METALS, SOLV, PET	CARBC;IC
C-3-020	3	AOC	Underground tanks	Inactive	185	ORG, INORG, METALS, SOLV, PET	CARBC;IC
C-3-021	3	AOC	Underground tank	Active	0		CARBC;IC
C-3-022	3	AOC	Tank	Inactive	0		CARBC;IC
30-001	30	A SWMU	Surface disposal and landfill	Anactive	1111	ORG, INORG, METALS	CARBC;IC
59-001	59	A SWMU	Septic system	Decommission	94	ORG, INORG, METALS, PHOCHEM	CARBC;IC
59-002	59	88 SWMU	Container storage area	Active	6	RAD, ORG, INORG, METALS	CARBC;IC
59-003	59	88 SWMU	Sumps	Active	0	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
59-004	59	90 SWMU	Outfall	Active	37	ORG, INORG, METALS	CARBC;IC
C-59-001	59	AOC	Transformer	Active	0		CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
60-001(a)	60	88 SWMU	Storage area	Active	4	ORG, INORG, METALS, SOLV, PET	CARBC;IC
60-001(b)	60	88 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
60-001(c)	60	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
60-001(d)	60	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PESTICIDES	CARBC;IC
60-002	60	A SWMU	Surface disposal	Inactive	807	ORG, INORG, METALS	CARBC;IC
60-003	60	88 SWMU	Sump	Active	8	ORG, INORG, METALS, PET	CARBC;IC
60-004(a)	60	88 SWMU	Storage area	Active	134	ORG, INORG, METALS, PET	CARBC;IC
60-004(b)	60	88 SWMU	Storage area	Active	20	ORG, INORG, METALS, SOLV, PET	CARBC;IC
60-004(c)	60	88 SWMU	Storage area	Active	3	ORG, INORG, METALS	CARBC;IC
60-004(d)	60	90 SWMU	Storage area	Active	4	ORG, INORG, METALS, PET	CARBC;IC
60-004(e)	60	90 SWMU	Storage area	Active	46	ORG, INORG, METALS, PET, PCB	CARBC;IC
60-005(a)	60	B SWMU	Surface impoundment	Inactive	124	RAD, ORG, INORG, METALS	CARBC;IC
60-005(b)	60	88 SWMU	Surface impoundment	Inactive	267	ORG, INORG, METALS	CARBC;IC
60-006(a)	60	88 SWMU	Septic system	Active	5	ORG, INORG, METALS, SOLV	CARBC;IC
60-006(b)	60	90 SWMU	Septic system	Active	3	ORG, INORG, METALS, SOLV	CARBC;IC
60-006(c)	60	90 SWMU	Septic system	Active	4	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
60-007(a)	60	90 SWMU	Systematic leak	Inactive	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
60-007(b)	60	90 SWMU	Occasional spill	Inactive	6	ORG, INORG, METALS, SOLV, PET	CARBC;IC
C-60-001	60	AOC	Underground tank	Removed	74	ORG, INORG, METALS	CARBC;IC
C-60-002	60	AOC	Underground tank	Removed	67	ORG, INORG, METALS, SOLV, PET	CARBC;IC
C-60-003	60	AOC	One-time spill	Inactive	0		CARBC;IC
C-60-004	60	AOC	Underground tank	Removed	74	ORG, INORG, METALS, SOLV, PET	CARBC;IC
61-001	61	88 SWMU	Storage area	Active	269	ORG, INORG, METALS, PCB	CARBC;IC
61-002	61	A SWMU	Storage area	Decommission	494	ORG, INORG, METALS, PET, PCB	CARBC;IC
61-003	61	88 SWMU	Burn sites	Decommission	377	RAD, HE, ORG, INORG, METALS	CARBC;IC
61-004(a)	61	88 SWMU	Septic system	Inactive	11	RAD, ORG, INORG, METALS	CARBC;IC
61-004(b)	61	88 SWMU	Septic system	Inactive	11	ORG, INORG, METALS	CARBC;IC
61-004(c)	61	91 SWMU	Septic system	Inactive	11	RAD	CARBC;IC
61-005	61	SWMU	Landfill	Active	313630	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
61-006	61	SWMU	Container storage	Active	0	ORG, INORG, METALS, PET	CARBC;IC
61-007	61	SWMU	Systematic leak	Inactive	600	ORG, INORG, METALS, PCB	CARBC;IC
C-61-001	61	AOC	Transformer	Active	7	ORG, INORG, METALS, PCB	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
64-001	64	90 SWMU	Storage area	Active	5	ORG, INORG, METALS, SOLV	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
33-001(a)	33	A SWMU	Material disposal area	Inactive	292	RAD, HE, ORG, INORG, METALS	IS;IC
33-001(b)	33	A SWMU	Material disposal area	Inactive	175	RAD, HE, ORG, INORG, METALS	IS;IC
33-001(c)	33	A SWMU	Material disposal area	Inactive	4	RAD, HE, ORG, INORG, METALS	IS;IC
33-001(d)	33	A SWMU	Material disposal area	Inactive	389	RAD, HE, ORG, INORG, METALS	IS;IC
33-001(e)	33	A SWMU	Material disposal area	Inactive	148	RAD, HE, ORG, INORG, METALS	IS;IC
33-001(misc)	33	88 SWMU	Material disposal area	Inactive	0		IS;IC
33-002(a)	33	B SWMU	Septic tank	Active	157	RAD, ORG, INORG, METALS, SOLV	IS;IC
33-002(b)	33	B SWMU	Sump	Inactive	203	RAD, ORG, INORG, METALS, SOLV	IS;IC
33-002(c)	33	B SWMU	Sump	Inactive	203	RAD, ORG, INORG, METALS, SOLV	IS;IC
33-002(d)	33	90 SWMU	Drain line and outfall	Inactive	1	RAD, ORG, INORG, METALS	IS;IC
33-002(e)	33	90 SWMU	Drain line and outfall	Active	1	RAD, ORG, INORG, METALS	IS;IC
33-003(a)	33	A SWMU	Material disposal area	Inactive	144	RAD, METALS	IS;IC
33-003(b)	33	A SWMU	Material disposal area	Inactive	144	RAD, METALS	IS;IC
33-004(a)	33	A SWMU	Septic system	Active	102	RAD, ORG, INORG, METALS	CARBC;IC
33-004(b)	33	A SWMU	Septic system	Active	6	RAD, ORG, INORG, METALS	CARBC;IC
33-004(c)	33	A SWMU	Septic system	Active	12	RAD, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
33-004(d)	33	A SWMU	Septic system	Inactive	24	RAD, ORG, INORG, METALS	CARBC;IC
33-004(e)	33	A SWMU	Septic system	Inactive	9	RAD, ORG, INORG, METALS	rec NFA
33-004(f)	33	A SWMU	Septic system	Active	4	RAD, ORG, INORG, METALS	rec NFA
33-004(g)	33	90 SWMU	Outfall	Active	17	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-004(h)	33	90 SWMU	Outfall	Inactive	34	RAD, ORG, INORG, METALS	CARBC;IC
33-004(i)	33	90 SWMU	Outfall	Inactive	25	RAD, ORG,INORG, METALS	CARBC;IC
33-004(j)	33	90 SWMU	Outfall	Inactive	21	RAD, ORG, INORG, METALS	CARBC;IC
33-004(k)	33	90 SWMU	Outfall	Inactive	16	RAD, ORG, INORG, METALS	CARBC;IC
33-004(l)	33	90 SWMU	Outfall	Inactive	29	RAD, ORG, INORG, METALS	rec NFA
33-004(m)	33	90 SWMU	Septic system	Active	5	RAD, ORG, INORG, METALS	CARBC;IC
33-004(n)	33	90 SWMU	Septic system	Active	5	RAD, ORG, INORG, METALS	rec NFA
33-004(misc)	33	88 SWMU	Septic system	Active	0		CARBC;IC
33-005(a)	33	88 SWMU	Septic system	Decommission	31	RAD, ORG, INORG, METALS	CARBC;IC
33-005(b)	33	88 SWMU	Septic system	Decommission	21	RAD, ORG, INORG, METALS	CARBC;IC
33-005(c)	33	88 SWMU	Septic system	Decommission	550	RAD, ORG, INORG, METALS	CARBC;IC
33-006(a)	33	88 SWMU	Firing site	Decommission	1667	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
33-006(b)	33	88 SWMU	Firing range	Decommission	2708	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-007(a)	33	A SWMU	Firing range	Decommission	2685	RAD, HE, ORG, INORG, METALS, PET	CARBC;IC
33-007(b)	33	A SWMU	Firing range	Decommission	1917	RAD, HE, ORG, INORG, METALS, PET	CARBC;IC
33-007(c)	33	A SWMU	Firing range	Decommission	611	RAD, HE, ORG, INORG, METALS, PET	CARBC;IC
33-008(a)	33	A SWMU	Landfill	Inactive	1389	HE, ORG, INORG, METALS	CARBC;IC
33-008(b)	33	A SWMU	Landfill	Inactive	1389	HE, ORG, INORG, METALS	CARBC;IC
33-009	33	A SWMU	Surface disposal	Decommission	1925	RAD, HE, ORG, INORG, METALS, PCB	CARBC;IC
33-010(a)	33	A SWMU	Surface disposal	Inactive	810	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-010(b)	33	A SWMU	Surface disposal	Inactive	1667	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-010(c)	33	A SWMU	Surface disposal	Inactive	2333	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-010(d)	33	90 SWMU	Surface disposal	Inactive	3500	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-010(e)	33	90 SWMU	Surface disposal	Inactive	1167	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-010(f)	33	90 SWMU	Surface disposal	Inactive	1750	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-010(g)	33	90 SWMU	Surface disposal	Inactive	7963	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-010(h)	33	90 SWMU	Surface disposal	Inactive	7750	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-011(a)	33	A SWMU	Storage area	Inactive	102	ORG, INORG, PET, PCB	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
33-011(b)	33	90 SWMU	Storage area	Inactive	3333	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-011(c)	33	90 SWMU	Storage area	Inactive	79	RAD, ORG, INORG, METALS	CARBC;IC
33-011(d)	33	90 SWMU	Storage area	Inactive	292	RAD, ORG, INORG, METALS	CARBC;IC
33-011(e)	33	90 SWMU	Storage area	Inactive	185	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-012(a)	33	A SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV, PCB	CARBC;IC
33-012(b)	33	88 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, PHOCHEM	rec NFA
33-012(c)	33	88 SWMU	Satellite storage	Active	1	ORG, INORG, METALS	rec NFA
33-012(d)	33	88 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	rec NFA
33-013	33	A SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
33-014	33	A SWMU	Burn site	Inactive	4033	RAD, HE, ORG, INORG, METALS	CARBC;IC
33-015	33	88 SWMU	Incinerator	Inactive	1	ORG, INORG	CARBC;IC
33-016	33	88 SWMU	Sump	Inactive	17	HE, ORG, INORG, METALS, PET	CARBC;IC
33-017	33	B SWMU	Occasional spill	Active	1062	RAD, ORG, INORG, METALS	CARBC;IC
C-33-001	33	AOC	Transformer	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
C-33-002	33	AOC	Transformer	Removed	0		CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
4-001	4	A SWMU	Firing site	Decommission	741	RAD, HE, ORG, INORG, METALS	CARBC;IC
4-002	4	A SWMU	Surface disposal	Inactive	35	RAD, HE, ORG, INORG, METALS	CARBC;IC
4-003(a)	4	90 SWMU	Outfall	Decommission	116	RAD, ORG, INORG, METALS, PHOCHEM	CARBC;IC
4-003(b)	4	90 SWMU	Outfall	Inactive	116	ORG, INORG, METALS	CARBC;IC
4-004	4	90 SWMU	Laboratory	Inactive	17	RAD, ORG, INORG, METALS, PHOCHEM	CARBC;IC
C-4-001	4	AOC	Buildings	Removed	0		rec NFA
5-001(a)	5	A SWMU	Firing site	Decommission	748	RAD, HE, ORG, INORG, METALS	CARBC·IC
5-001(b)	5	A SWMU	Firing site	Decommission	748	RAD, HE, ORG, INORG, METALS	CARBC;IC
5-001(c)	5	90 SWMU	Firing site	Decommission	748	HE, ORG, INORG, METALS	CARBC;IC
5-002	5	A SWMU	Surface disposal	Inactive	726	RAD, ORG, INORG, METALS	CARBC;IC
5-003	5	A SWMU	Operational facility	Inactive	0	RAD, ORG, INORG, METALS	rec NFA
5-004	5	A SWMU	Septic system	Decommission	9	RAD, ORG, INORG, METALS	CARBC;IC
5-005(a)	5	B SWMU	Waste lines	Decommission	111	RAD, ORG, INORG, METALS	CARBC;IC
5-005(b)	5	90 SWMU	Outfall	Inactive	111	ORG, INORG, METALS, PHOCHEM	CARBC;IC
5-006(a)	5	90 SWMU	Laboratory	Inactive	0		rec NFA
5-006(b)	5	90 SWMU	Building	Inactive	3	RAD, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
5-006(c)	5	90 SWMU	Building	Inactive	3	HE, ORG, INORG, METALS, PHOCHEM	CARBC;IC
5-006(d)	5	90 SWMU	Laboratory	Inactive	0		rec NFA
5-006(e)	5	90 SWMU	Building	inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
5-006(f)	5	90 SWMU	Building	Inactive	0		rec NFA
5-006(g)	5	90 SWMU	Building	Inactive	0		rec NFA
5-006(h)	5	90 SWMU	Building	Inactive	1	RAD, ORG, INORG, METALS	CARBC;IC
C-5-001	5	AOC	Buildings	Removed	3704	ORG, INORG, METALS	CARBC;IC
35-001	35	88 SWMU	Material disposal area	Inactive	0		rec NFA
35-002	35	88 SWMU	Material disposal area	Inactive	0		rec NFA
35-003(a)	35	B SWMU	Waste water treatment facility	Inactive	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(b)	35	B SWMU	Waste water treatment facility	Inactive	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(c)	35	B SWMU	Waste water treatment facility	inactive	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(d)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(e)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(f)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(g)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(h)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
35-003(i)	35	B SWMU	Waste water treatment facility	Decommission	0		rec NFA
35-003(j)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(k)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(l)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(m)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(n)	35	B SWMU	Waste water treatment facility	Inactive	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(o)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(p)	35	B SWMU	Waste water treatment facility	Inactive	0		rec NFA
35-003(q)	35	B SWMU	Waste water treatment facility	Decommission	65488	RAD, ORG, INORG, METALS	CARBC;IC
35-003(r)	35	90 SWMU	Outfall	Inactive	3986	RAD, ORG, INORG, METALS	CARBC;IC
35-004(a)	35	88 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
35-004(b)	35	88 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
35-004(c)	35	88 SWMU	Storage area	Active	0		rec NFA
35-004(d)	35	88 SWMU	Storage area	Active	0		rec NFA
35-004(e)	35	A SWMU	Storage area	Active	0		rec NFA
35-004(f)	35	88 SWMU	Storage area	Active	0		rec NFA

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
35-004(g)	35	88 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
35-004(h)	35	88 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
35-004(i)	35	88 SWMU	Storage area	Active	0		rec NFA
35-004(j)	35	88 SWMU	Storage area	Active	0		rec NFA
35-004(k)	35	90 SWMU	Storage area	Active	0		rec NFA
35-004(l)	35	90 SWMU	Storage area	Active	0		rec NFA
35-004(m)	35	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
35-004(n)	35	90 SWMU	Storage area	Active	0		rec NFA
35-004(o)	35	90 SWMU	Storage area	Active	0		rec NFA
35-005(a)	35	88 SWMU	Surface impoundment	Inactive	0		rec NFA
35-005(b)	35	88 SWMU	Surface impoundment	Inactive	0		rec NFA
35-006	35	B SWMU	Surface impoundment	Decommission	0		rec NFA
35-007	35	88 SWMU	Oil recovery unit	Active	0		rec NFA
35-008	35	A SWMU	Surface disposal and landfill	Inactive	1389	ORG, INORG, METALS	CARBC;IC
35-009(a)	35	A SWMU	Septic system	Inactive	120	ORG, INORG, METALS	CARBC;IC
35-009(b)	35	A SWMU	Septic system	Inactive	633	ORG, INORG, METALS	CARBC;IC
35-009(c)	35	A SWMU	Septic system	Active	278	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
35-009(d)	35	A SWMU	Septic system	Active	254	ORG, INORG, METALS	CARBC;IC
35-009(e)	35	A SWMU	Septic system	Unknown	47	ORG, INORG, METALS	CARBC;IC
35-010(a)	35	B SWMU	Surface impoundment	active	10489	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
35-010(b)	35	B SWMU	Surface impoundment	Active	8519	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
35-010(c)	35	B SWMU	Surface impoundment	Active	8944	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
35-010(d)	35	B SWMU	Filter system	Active	3333	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
35-010(e)	35	88 SWMU	Surface impoundment	Active	50		CARBC;IC
35-011(a)	35	88 SWMU	Underground tank	Active	0		rec NFA
35-011(b)	35	88 SWMU	Underground tank	Active	0		rec NFA
35-011(c)	35	88 SWMU	Underground tank	Active	0		rec NFA
35-011(d)	35	90 SWMU	Underground tank	Active	0		rec NFA
35-012(a)	35	88 SWMU	Underground tank	Unknown	0		rec NFA
35-012(b)	35	90 SWMU	Underground tank	Unknown	0		rec NFA
35-013(a)	35	88 SWMU	Sump	Active	0		rec NFA
35-013(b)	35	88 SWMU	Sump	Active	0		rec NFA
35-013(c)	35	88 SWMU	Sump	Active	0		rec NFA
35-013(d)	35	88 SWMU	Waste lines and drain lines	Active	0		rec NFA
35-014(a)	35	A SWMU	Non-intentional release area	Inactive	208	RAD, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
35-014(b)	35	A SWMU	Systematic leak	Inactive	1	RAD, ORG, INORG, METALS, PCB, PET	CARBC;IC
35-014(c)	35	90 SWMU	Occasional spill	Inactive	0		rec NFA
35-014(d)	35	90 SWMU	Occasional spill	Inactive	1	RAD, ORG, INORG, METALS, PET	CARBC;IC
35-014(e)	35	90 SWMU	One-time spills	Inactive	2	RAD, ORG, INORG, METALS, PET	CARBC;IC
35-014(f)	35	90 SWMU	Systematic leak	Inactive	1	RAD, ORG, INORG, METALS, PET	CARBC;IC
35-014(g)	35	90 SWMU	One-time spills	Inactive	56	RAD, ORG, INORG, METALS, PET	CARBC;IC
35-015(a)	35	88 SWMU	Tanks	Decommission	2667	ORG, INORG, METALS, PET	CARBC;IC
35-015(b)	35	A SWMU	Oil recovery unit	Decommission	556	ORG, INORG, METALS, PET	CARBC;IC
35-016(a)	35	90 SWMU	Outfall	Inactive	47	ORG, INORG, METALS	CARBC;IC
35-016(b)	35	90 SWMU	Outfall	Active	47	ORG, INORG, METALS	CARBC;IC
35-016(c)	35	90 SWMU	Outfalls	Inactive	47	ORG, INORG, METALS	CARBC;IC
35-016(d)	35	90 SWMU	Outfall	Inactive	47	ORG, INORG, METALS	CARBC;IC
35-016(e)	35	90 SWMU	Outfall	Inactive	93	ORG, INORG, METALS	CARBC;IC
35-016(f)	35	90 SWMU	Storm drainage	Active	94	ORG, INORG, METALS	CARBC;IC
35-016(g)	35	90 SWMU	Outfall	Active	93	ORG, INORG, METALS	CARBC;IC
35-016(h)	35	90 SWMU	Storm drainages	Active	101	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
35-016(i)	35	90 SWMU	Storm drainage	Active	94	ORG, INORG, METALS	CARBC;IC
35-016(j)	35	90 SWMU	Storm drainage	Active	48	ORG, INORG, METALS	CARBC;IC
35-016(k)	35	90 SWMU	Outfall	Inactive	46	ORG, INORG, METALS	CARBC;IC
35-016(l)	35	90 SWMU	storm drainage	Active	48	RAD, ORG, INORG, METALS	CARBC;IC
35-016(m)	35	90 SWMU	Outfall	Inactive	93	ORG, INORG, METALS	CARBC;IC
35-016(n)	35	90 SWMU	Storm drainage	Active	48	ORG, INORG, METALS	CARBC;IC
35-016(o)	35	90 SWMU	Storm drainage	Active	96	ORG, INORG, METALS	CARBC;IC
35-016(p)	35	90 SWMU	Outfall	Active	93	ORG, INORG, METALS	CARBC;IC
35-016(q)	35	90 SWMU	Storm drainage	Active	315	RAD, ORG, INORG, METALS	CARBC;IC
35-017	35	90 SWMU	Reactor facility	Inactive	1157	RAD, ORG, INORG, METALS	CARBC;IC
35-018(a)	35	90 SWMU	Transformer	Unknown	0		rec NFAI
35-018(b)	35	90 SWMU	Transformer	Unknown	0		rec NFA
C-35-001	35	AOC	Underground tank	Removed	0		rec NFA
C-35-002	35	AOC	Underground tank	Removed	0		rec NFA
C-35-003	35	AOC	Underground tank	Removed	0		rec NFA
C-35-004	35	AOC	One-time spill	Cleaned up	0		rec NFA

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-35-005	35	AOC	One-time spill	Cleaned up	0		rec NFA
C-35-006	35	AOC	One-time spill	Removed	0		rec NFA
C-35-007	35	AOC	One-time spill	Unknown	111	ORG, INORG, METALS	CARBC;IC
C-35-008	35	AOC	Transformer and systematic leak	Active	0		rec NFA
42-001(a)	42	88 SWMU	Incinerator	Decommission	3161	RAD, ORG, INORG, METALS	CARBC;IC
42-001(b)	42	88 SWMU	Underground tank	Decommission	14	RAD, ORG, INORG, METALS	CARBC;IC
42-001(c)	42	88 SWMU	Underground tank	Decommission	14	RAD, ORG, INORG, METALS	CARBC;IC
42-002(a)	42	88 SWMU	Decontamination facility	Decommission	3161	RAD, ORG, INORG, METALS, SOLV, ACID	CARBC;IC
42-002(b)	42	90 SWMU	Decontamination facility	Decommission	14	RAD, ORG, INORG, METALS	CARBC;IC
42-003	42	88 SWMU	Septic system	Decommission	1573	RAD, ORG, INORG, METALS, SOLV, ACID	CARBC;IC
42-004	42	90 SWMU	Surface disposal	Inactive	0		rec NFA
C-42-001	42	AOC	Surface disposal	Inactive	0		rec NFA
48-001	48	88 SWMU	Systematic release site	Active	10895	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
48-002(a)	48	A SWMU	Container storage	Inactive	4	ORG, INORG, METALS	CARBC;IC
48-002(b)	48	90 SWMU	Container storage	Inactive	3	ORG, INORG, METALS	CARBC;IC
48-002(c)	48	A SWMU	Container storage	Inactive	7	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
48-002(d)	48	90 SWMU	Container storage	Inactive	0		rec NFA
48-002(e)	48	90 SWMU	Container storage	Active	1	RAD, ORG, INORG, METALS	CARBC;IC
48-003	48	A SWMU	Septic system	Inactive	532	RAD, ORG, INORG, METALS	CARBC;IC
48-004(a)	48	88 SWMU	Sump	Inactive	0		rec NFA
48-004(b)	48	88 SWMU	Aboveground tanks and sump	Inactive	0		rec NFA
48-004(c)	48	88 SWMU	Aboveground tank	Inactive	0		rec NFA
48-004(d)	48	88 SWMU	Underground tank	Inactive	0		rec NFA
48-005	48	A SWMU	Waste lines	inactive/d	0		rec NFA
48-006	48	88 SWMU	Septic system	Active	0		rec NFA
48-007(a)	48	90 SWMU	Outfall	Active	116	ORG, INORG, METALS	CARBC;IC
48-007(b)	48	90 SWMU	Outfall	Active	116	ORG, INORG, METALS	CARBC;IC
48-007(c)	48	90 SWMU	Outfall	Active	116	ORG, INORG, METALS	CARBC;IC
48-007(d)	48	90 SWMU	Outfall	Active	93	ORG, INORG, METALS	CARBC;IC
48-007(e)	48	90 SWMU	Outfall	Active	0		rec NFA
48-007(f)	48	90 SWMU	Outfall	Active	116	ORG, INORG, METALS	CARBC;IC
48-008	48	90 SWMU	Transformer	Decommission	0		rec NFA
48-009	48	90 SWMU	Machinery	Active	0		rec NFA

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PRS Information for OU # 1129

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
48-010	48	90 SWMU	Surface impoundment	Active	417	RAD, ORG, INORG, METALS	CARBC;IC
48-011	48	RFI SWMU	Disposal shaft	Inactive	0		rec NFA
52-001(a)	52	A SWMU	Filter system	Decommission	0		rec NFA
52-001(b)	52	A SWMU	Reactor facility	Decommission	0		rec NFA
52-001(c)	52	A SWMU	Reactor facility	Decommission	0		rec NFA
52-001(d)	52	A SWMU	Reactor facility	Inactive	0		rec NFA
52-002(a)	52	A SWMU	Septic system	Active	14	ORG, INORG, METALS, SOLV	CARBC;IC
52-002(b)	52	A SWMU	Septic system	Active	0		rec NFA
52-002(c)	52	A SWMU	Septic system	Active	0		rec NFA
52-002(d)	52	A SWMU	Septic system	Active	0		rec NFA
52-002(f)	52	A SWMU	Septic system	Active	0		rec NFA
52-002(g)	52	90 SWMU	Septic system	Active	0		rec NFA
52-003(a)	52	90 SWMU	Waste treatment facility	Decommission	0		rec NFA
52-003(b)	52	90 SWMU	Waste treatment facility	Decommission	0		rec NFA
52-004	52	90 SWMU	0outfall	Active	0		rec NFA
C-52-001	52	AOC	Transformer	Active	0		rec NFA
C-52-002	52	AOC	Transformer	Active	0		rec NFAC

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PRS Information for OU # 1129

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
55-001	55	88 SWMU	Packaging site	Active	0		rec NFA
55-002(a)	55	88 SWMU	Container storage	Active	0		rec NFA
55-002(b)	55	90 SWMU	Container storage	Active	0		rec NFA
55-002(c)	55	RFI SWMU	Container storage	Active	0		rec NFA
55-003	55	88 SWMU	Aboveground tank	Active	0		rec NFA
55-004	55	88 SWMU	Reduction site	Active	0		rec NFA
55-005	55	88 SWMU	Filter system	Active	0		rec NFA
55-006	55	88 SWMU	Reduction site	Active	0		rec NFA
55-007	55	88 SWMU	Incinerator	Active	0		rec NFA
55-008	55	88 SWMU	Sumps and tanks	Active	0		rec NFA
55-009	55	88 SWMU	Sump	Unknown	0		rec NFA
55-010	55	90 SWMU	One-time spill	Inactive	0		rec NFA
55-011(a)	55	90 SWMU	Outfall	Active	20	RAD, ORG, INORG, METALS	CARBC;IC
55-011(b)	55	90 SWMU	Outfall	Active	11	RAD, ORG, INORG, METALS	CARBC;IC
55-011(c)	55	90 SWMU	Outfall	Active	9	RAD, ORG, INORG, METALS	CARBC;IC
55-011(d)	55	90 SWMU	Outfall	Active	13	RAD, ORG, INORG, METALS	CARBC;IC
55-011(e)	55	90 SWMU	Outfall	Active	8	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1129

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
55-012	55	90 SWMU	Storage area	Inactive	0		rec NFA
55-013(a)	55	90 SWMU	Storage area	Active	0		rec NFA
55-013(b)	55	90 SWMU	Storage area	Active	0		rec NFA
63-001(a)	63	90 SWMU	Septic system	Active	11	ORG, INORG, METALS	CARBC;IC
63-001(b)	63	90 SWMU	Septic system	Active	11	ORG, INORG, METALS, SOLV	CARBC;IC
63-002	63	RFI SWMU	Container storage	Active	0		rec NFA

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PRS Information for OU # 1129

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
35-003 Misc	35	88 SWMU	Piping and retention tank	Inactive	65488	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1130

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
36-001	36	A SWMU	Material disposal area	Inactive	13777	RAD, HE, ORG, INORG, METALS	CARBC;IC
36-002	36	A SWMU	Sump	Active	1	HE, ORG, INORG, METALS	CARBC;IC
36-003(a)	36	B SWMU	Septic system	Active	1330	RAD,ORG,INORG,METALS,SOLV,PHOCHEM	CARBC;IC
36-003(b)	36	B SWMU	Septic system	Active	2		rec NFA
36-003(c)	36	B SWMU	Septic system	Active	3	ORG, INORG, METALS	CARBC;IC
36-003(d)	36	90 SWMU	Septic system	Active	90	ORG, INORG, METALS	CARBC;IC
36-004(a)	36	88 SWMU	Firing site	Active	2327	RAD, HE, ORG, INORG, METALS, ACIDS	CARBC;IC
36-004(b)	36	88 SWMU	Firing site	Active	2327	RAD, HE, ORG, INORG, METALS	CARBC;IC
36-004(c)	36	88 SWMU	Firing site	Active	20943	RAD, HE, ORG, INORG, METALS	CARBC;IC
36-004(d)	36	88 SWMU	Firing site	Active	9493	RAD, HE, ORG, INORG, METALS	CARBC;IC
36-004(e)	36	88 SWMU	Firing site	Inactive	2327	RAD, HE, ORG, INORG, METALS	CARBC;IC
36-004(f)	36	88 SWMU	Firing site	Active	20943	RAD, HE, ORG, INORG, METALS	CARBC;IC
36-005	36	A SWMU	Surface disposal	Active	833	RAD, ORG, INORG, METALS	CARBC;IC
36-006	36	88 SWMU	Surface disposal	Inactive	139	ORG, INORG, METALS	CARBC;IC
36-007(a)	36	88 SWMU	Storage area	Active	1	HE, ORG, INORG, METALS	rec NFA
36-007(b)	36	88 SWMU	Storage area	Active	1	HE, ORG, INORG, METALS	rec NFA

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PRS Information for OU # 1130

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
36-007(c)	36	88 SWMU	Storage area	Active	1	HE, ORG, INORG, METALS	rec NFA
36-007(d)	36	88 SWMU	Storage area	Active	1	HE, ORG, INORG, METALS	rec NFA
36-007(e)	36	88 SWMU	Storage area	Active	8	HE, ORG, INORG, METALS	rec NFA
36-007(f)	36	88 SWMU	Storage area	Inactive	8	HE, ORG, INORG, METALS	rec NFA
36-009	36	88 SWMU	Mortar impact area	Inactive	1008	HE, ORG, INORG, METALS	CARBC;IC
C-36-001	36	AOC	Building	Unknown	0		CARBC;IC
C-36-002	36	AOC	Surface disposal	Inactive	0		rec NFA
C-36-003	36	AOC	Storm drainages	Active	33		rec NFA

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PRS Information for OU # 1132

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
39-001(a)	39	B SWMU	Landfill	Inactive	44445	RAD, ORG, INORG, METALS, PCB	CARBC;IC
39-001(b)	39	B SWMU	Material disposal area	Inactive	133333	RAD, ORG, INORG, METALS, PCB	CARBC;IC
39-002(a)	39	A SWMU	Storage area	Active	2	ORG, INORG, METALS, SOLV	CARBC;IC
39-002(b)	39	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
39-002(c)	39	88 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
39-002(d)	39	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
39-002(e)	39	90 SWMU	Storage area	Active	1	INORG, METALS	CARBC;IC
39-002(f)	39	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
39-002(g)	39	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
39-003	39	A SWMU	Incinerator	Decommission	101	RAD, HE, ORG, INORG, METALS	CARBC;IC
39-004(a)	39	88 SWMU	Firing site	Inactive	58182	RAD, HE, ORG, INORG, METALS, PCB	CARBC;IC
39-004(b)	39	88 SWMU	Firing site	Inactive	58182	RAD, HE, ORG, INORG, METALS, PCB	CARBC;IC
39-004(c)	39	A SWMU	Firing site	Active	58182	RAD, HE, ORG, INORG, METALS, PCB	CARBC;IC
39-004(d)	39	A SWMU	Firing site	Active	58182	RAD, HE, ORG, INORG, METALS, PCB	CARBC;IC
39-004(e)	39	A SWMU	Firing site	Active	58182	RAD, HE ORG, INORG, METALS, PCB	CARBC;IC
39-005	39	88 SWMU	Sump	Decommission	1140	HE, ORG, INORG, METALS, SOLV	CARBC;IC

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PRS Information for OU # 1132

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
39-006(a)	39	A SWMU	Septic system	Active	448	ORG, INORG, METALS, PHOCHEM	CARBC;IC
39-006(b)	39	90 SWMU	Septic system	Active	417	ORG, INORG, METALS, PHOCHEM	CARBC;IC
39-007(a)	39	A SWMU	Storage area	Inactive	1	ORG, INORG, METALS, SOLV	CARBC;IC
39-007(b)	39	88 SWMU	Storage area	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
39-007(c)	39	88 SWMU	Storage area	Inactive	2	ORG, INORG, METALS	CARBC;IC
39-007(d)	39	88 SWMU	Storage area	Inactive	2	ORG, INORG, METALS	CARBC;IC
39-007(e)	39	90 SWMU	Storage area	Inactive	2	ORG, INORG, METALS, SOLV	CARBC;IC
39-008	39	90 SWMU	Firing range	Inactive	278	RAD, ORG, INORG, METALS	CARBC;IC
39-009	39	90 SWMU	Outfall	Active	57	ORG, INORG, METALS	CARBC;IC
C-39-001	39	AOC	One-time spill	Removed	0		CARBC;IC
C-39-002	39	AOC	One-time spills	Removed	0		CARBC;IC

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PRS Information for OU # 1136

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
43-001(a)	43	A SWMU	Waste lines	Active/ina	2	RAD, ORG, INORG, METALS	CARBC;IC
43-001(b)	43	90 SWMU	Waste lines	Active/ina	1	RAD, ORG, INORG, METALS	CARBC;IC
43-002	43	88 SWMU	Incinerator	Active	4	ORG, INORG, METALS	rec NFA
43-003	43	88 SWMU	Building	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
43-004	43	88 SWMU	Storage area	Active	6	ORG, INORG, METALS	CARBC;IC
43-005	43	90 SWMU	Aboveground tank	Active	2	RAD, ORG, INORG, METALS	CARBC;IC
C-43-001	43	AOC	Storm drainage	Active	370	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1140

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
46-001	46	88 SWMU	Aboveground tank	Active	41	ORG, INORG, METALS, ACIDS	CARBC;IC
46-002	46	B SWMU	Surface impoundment	Active	378	RAD,ORG,INORG,METALS,ACIDS,SOLV	CARBC;IC
46-003(a)	46	A SWMU	Septic system	Inactive	7	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
46-003(b)	46	A SWMU	Septic system	Inactive	7	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
46-003(c)	46	A SWMU	Septic system	Inactive	7	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
46-003(d)	46	A SWMU	Septic system	Inactive	7	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
46-003(e)	46	A SWMU	Septic system	Inactive	7	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
46-003(f)	46	A SWMU	Septic system	Inactive	7	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
46-003(g)	46	A SWMU	Septic system	Active	7	RAD, ORG, INORG, METALS	CARBC;IC
46-003(h)	46	90 SWMU	Septic system	Inactive	5	RAD, ORG, INORG, METALS	CARBC;IC
46-004(a)	46	A SWMU	Waste line	Inactive	5	ORG, INORG, METALS	CARBC;IC
46-004(b)	46	A SWMU	Waste line	Inactive	1	ORG, INORG, METALS	CARBC;IC
46-004(c)	46	A SWMU	Sump	Inactive	117	RAD, ORG, INORG, METALS	CARBC;IC
46-004(d)	46	A SWMU	Sump	Inactive	58	RAD,ORG,INORG,METALS,SOLV,ACIDS	CARBC;IC
46-004(e)	46	A SWMU	Sump	Inactive	58	RAD,ORG,INORG,METALS,SOLV,ACIDS	CARBC;IC
46-004(f)	46	A SWMU	Sump	inactive	59	ORG,INORG, METALS, ACIDS	CARBC;IC

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PRS Information for OU # 1140

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
46-004(g)	46	A SWMU	Sump	Inactive	1	RAD, ORG, INORG, METALS,	CARBC;IC
46-004(h)	46	A SWMU	Sump	Inactive	1	RAD, ORG, INORG, METALS	CARBC;IC
46-004(i)	46	90 SWMU	Outfall	Active	59	ORG, INORG, METALS, ACIDS	CARBC;IC
46-004(j)	46	90 SWMU	Outfall	Active	59	ORG, INORG, METALS, ACIDS	CARBC;IC
46-004(k)	46	90 SWMU	Outfall	Active	5	ORG, INORG, METALS, ACIDS	CARBC;IC
46-004(l)	46	90 SWMU	Reactor facility	Inactive	5	ORG, INORG, METALS, ACIDS	CARBC;IC
46-004(m)	46	90 SWMU	Outfall	Active	5	ORG, INORG, METALS, ACIDS	CARBC;IC
46-004(n)	46	90 SWMU	Outfall	Active	5	ORG, INORG, METALS, ACIDS	CARBC;IC
46-004(o)	46	90 SWMU	Outfall	Active	5	ORG, INORG, METALS, ACIDS	CARBC;IC
46-005	46	A SWMU	Surface impoundment	Active	222	ORG, INORG, METALS	CARBC;IC
46-006(a)	46	B SWMU	Container storage	Inactive	11	RAD, ORG, INORG, METALS, PESTICIDE	CARBC;IC
46-006(b)	46	B SWMU	One-time spill	Active	11	ORG, INORG, METALS, PET	CARBC;IC
46-006(c)	46	B SWMU	One-time spill	Active	11	ORG, INORG, METALS, PET	CARBC;IC
46-006(d)	46	B SWMU	One-time spill	Active	11	ORG, INORG, METALS, PET	CARBC;IC
46-006(e)	46	90 SWMU	Effluent discharge	Inactive	59	ORG, INORG, METALS, PET	CARBC;IC
46-007	46	B SWMU	Decontamination facility	Inactive	13	RAD, METALS	CARBC;IC

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PRS Information for OU # 1140

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
46-008(a)	46	A SWMU	Storage area	Inactive	3	ORG, INORG, METALS	CARBC;IC
46-008(b)	46	A SWMU	Storage area	Inactive	6	ORG, INORG, METALS	CARBC;IC
46-008(c)	46	A SWMU	Storage area	Inactive	6	ORG, INORG, METALS	CARBC;IC
46-008(d)	46	A SWMU	Storage area	Inactive	3	ORG, INORG, METALS	CARBC;IC
46-008(e)	46	A SWMU	Storage area	Inactive	5	ORG, INORG, METALS	CARBC;IC
46-008(f)	46	A SWMU	Storage area	Inactive	5	ORG, INORG, METALS	CARBC;IC
46-008(g)	46	90 SWMU	Storage area	Inactive	26	ORG, INORG, METALS	CARBC;IC
46-008(misc)	46	88 SWMU	Storage area	Inactive	0		CARBC;IC
46-009(a)	46	88 SWMU	Surface disposal	Inactive	69	ORG, INORG, METALS	CARBC;IC
46-009(b)	46	90 SWMU	Surface disposal	Inactive	426	RAD, ORG, INORG, METALS, SOLV, ACID	CARBC;IC
46-010(a)	46	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, ACIDS, PET	CARBC;IC
46-010(b)	46	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PHOCHEM, PET	CARBC;IC
46-010(c)	46	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
46-010(d)	46	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
46-010(e)	46	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
46-010(f)	46	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1140

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
46-010(misc)	46	88 SWMU	Storage area	Active	0		CARBC;IC
C-46-001	46	AOC	One-time spill	Unknown	4	ORG, INORG, METALS	CARBC;IC
C-46-002	46	AOC	Non-intentional release area	Unknown	3704	RAD, ORG, INORG, METALS	CARBC;IC
C-46-003	46	AOC	Non-intentional release area	Unknown	3704	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1144

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
49-001(a)	49	B SWMU	Material disposal area	Inactive	3307	RAD, HE, ORG, INORG, METALS	IS;IC
49-001(b)	49	B SWMU	Material disposal area	Inactive	6732	RAD, HE, ORG, INORG, METALS	IS;IC
49-001(c)	49	B SWMU	Material disposal area	Inactive	1686	RAD, HE, ORG, INORG, METALS	IS;IC
49-001(d)	49	B SWMU	Material disposal area	Inactive	2257	RAD, HE, ORG, INORG, METALS	IS;IC
49-001(e)	49	B SWMU	Material disposal area	Inactive	5557	RAD, HE, ORG, INORG, METALS	IS;IC
49-001(f)	49	B SWMU	Material disposal area	Inactive	5580	RAD, HE, ORG, INORG, METALS	IS;IC
49-001(g)	49	B SWMU	Material disposal area	Inactive	2581	RAD, HE, ORG, INORG, METALS	CARBC;IC
49-001(misc)	49	88 SWMU	Material disposal area	Inactive	0		CARBC;IC
49-002	49	88 SWMU	Operational facility	Inactive	404	RAD, METALS	IS;IC
49-003	49	A SWMU	Leach field	Inactive	807	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
49-004	49	88 SWMU	Burn site and landfill	Inactive	5000	ORG, INORG, METALS	CARBC;IC
49-005(a)	49	88 SWMU	Landfill	Inactive	4444	ORG, INORG, METALS	CARBC;IC
49-005(b)	49	88 SWMU	Landfill	Inactive	5	ORG, INORG, METALS	CARBC;IC
49-006	49	88 SWMU	Sump	Inactive	19	ORG, INORG, METALS, PHOCHEM	CARBC;IC
49-007(a)	49	88 SWMU	Septic system	Active	5	ORG, INORG, METALS	CARBC;IC
49-007(b)	49	88 SWMU	Septic system	Active	7	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1144

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
49-008(a)	49	90 SWMU	Buildings	Inactive	33	RAD, ORG, INORG, METALS	IS;IC
49-008(b)	49	90 SWMU	Buildings	Inactive	39	RAD, ORG, INORG, METALS	IS;IC
49-008(c)	49	90 SWMU	Buildings	Inactive	6	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
49-008(d)	49	90 SWMU	Firing sites	Inactive	18	RAD, HE, ORG, INORG, METALS, ACIDS	CARBC;IC
49-009	49	90 SWMU	Underground tank	Decommission	37	ORG, INORG, METALS, PET	CARBC;IC

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PRS Information for OU # 1147

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
50-001(a)	50	A SWMU	Waste treatment facility	Active	10962	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
50-001(b)	50	90 SWMU	Waste lines and manholes	Active	77	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
50-002(a)	50	A SWMU	Underground tanks	Active	954	RAD, ORG, INORG, METALS	CARBC;IC
50-002(b)	50	A SWMU	Underground tank	Active	15	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
50-002(c)	50	A SWMU	Underground tank	Active	15	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
50-002(d)	50	90 SWMU	Underground tank	Active	34	ORG, INORG, METALS, ACIDS	CARBC;IC
50-002(e)	50	IWP SWMU	Underground tank	Active	2	PET	CARBC;IC
50-003(a)	50	88 SWMU	Storage area	Active	163	RAD, ORG, INORG, METALS	CARBC;IC
50-003(b)	50	88 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, ACIDS	rec NFA
50-003(c)	50	88 SWMU	Storage area	Active	11	RAD, ORG, INORG, METALS, ACIDS	rec NFA
50-003(d)	50	88 SWMU	Storage area	Active	9	ORG, INORG, METALS, ACIDS	rec NFA
50-003(e)	50	88 SWMU	Storage area	Active	1	ORG, INORG, METALS	rec NFA
50-004(a)	50	A SWMU	Waste lines	Decommission	4	RAD, ORG, INORG, METALS	CARBC;IC
50-004(b)	50	A SWMU	Waste lines	Decommission	37	RAD, ORG, INORG, METALS	CARBC;IC
50-004(c)	50	90 SWMU	Waste lines	Decommission	26	RAD, ORG, INORG, METALS	CARBC;IC
50-005	50	88 SWMU	Waste treatment facility	Inactive	119	ORG, INORG, METALS	rec NFA

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PRS Information for OU # 1147

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
50-006(a)	50	B SWMU	Occasional spill	Active	86	RAD, ORG, INORG, METALS	CARBC;IC
50-006(b)	50	90 SWMU	Occasional release site	Active	1	ORG, INORG, METALS	rec NFA
50-006(c)	50	B SWMU	Systematic release site	Active	963	RAD, ORG, INORG, METALS	CARBC;IC
50-006(d)	50	B SWMU	Effluent discharge	Active	20575	RAD, ORG, INORG, METALS	CARBC;IC
50-006(e)	50	90 SWMU	Aboveground tank	Active	40	ORG, INORG, METALS, PET	rec NFA
50-007	50	88 SWMU	Incinerator	Active	8324	RAD, ORG, INORG, METALS	CARBC;IC
50-008	50	88 SWMU	Reduction site	Active	756	RAD, ORG, INORG, METALS	CARBC;IC
50-009	50	B SWMU	Material disposal area	Inactive	135185	RAD, ORG, ACID, INORG, METALS	IS;IC
50-010	50	88 SWMU	Decontamination facility	Active	367	RAD, ORG, INORG, METALS	CARBC;IC
50-011(a)	50	A SWMU	Septic system	Decommission	22	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
50-011(b)	50	90 SWMU	Septic system	Active	5	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
50-011(misc)	50	88 SWMU	Septic system	Active	0		CARBC;IC
C-50-001	50	AOC	Transformer	Active	1	ORG, INORG, METALS, PCB	CARBC;IC

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PRS Information for OU # 1148

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
51-001	51	88 SWMU	Septic system	Active	0	ORG, INORG, METALS	CARBC;IC
51-002(a)	51	88 SWMU	Usage site	Active	0	ORG, INORG, METALS	rec NFA
51-002(b)	51	88 SWMU	Usage site	Active	0	ORG, INORG, METALS	rec NFA
C-51-001	51	AOC	Storage area	Active	0		rec NFA
C-51-002	51	AOC	Buildings	Removed	370	RAD, HE, ORG, INORG, METALS	rec NFA
54-001(a)	54	A SWMU	Storage area	Active	15	ORG, INORG, METALS	CARBC;IC
54-001(b)	54	88 SWMU	Storage area	Active	8	ORG, INORG, METALS	CARBC;IC
54-001(c)	54	A SWMU	Storage area	Active	15	ORG, INORG, METALS, SOLV, PET	rec NFA
54-001(d)	54	88 SWMU	Storage area	Active	59	ORG, INORG, METALS, SOLV, PET, PCB	CARBC;IC
54-001(e)	54	88 SWMU	Storage area	Active	111	ORG, INORG, METALS	CARBC;IC
54-001(f)	54	90 SWMU	Storage area	Active	15	ORG, INORG, METALS	rec NFA
54-002	54	88 SWMU	Container storage	Active	7	ORG, INORG, METALS	CARBC;IC
54-004	54	B SWMU	Material disposal area	Inactive	432	RAD, HE, ORG, INORG, METALS	IS;IC
54-005	54	B SWMU	Material disposal area	Active	14154	RAD,HE,ORG,INORG,METALS ,ASBESTOS	IS;IC
54-006	54	A SWMU	Material disposal area	Inactive	20067	RAD,HE,ORG,INORG,METALS ,ASBESTOS	IS;IC
54-007(a)	54	A SWMU	Septic system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1148

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
54-007(b)	54	A SWMU	Septic system	Active	5	RAD, ORG, INORG, METALS	CARBC;IC
54-007(c)	54	A SWMU	Septic system	Active	36	RAD, ORG, INORG, METALS	CARBC;IC
54-007(d)	54	88 SWMU	Septic system	Active	14	RAD, ORG, INORG, METALS	CARBC;IC
54-007(e)	54	88 SWMU	Septic system	Active	22	RAD, ORG, INORG, METALS	CARBC;IC
54-007(misc)	54	88 SWMU	Septic system	Active	0		CARBC;IC
54-008	54	88 SWMU	Underground tank	Active	1	RAD, ORG, INORG, METALS	rec NFA
54-009	54	88 SWMU	Aboveground tank	Active	6	RAD, ORG, INORG, METALS	CARBC;IC
54-010	54	88 SWMU	Underground tank	Active	1	RAD, ORG, INORG, METALS	rec NFA
54-012(a)	54	88 SWMU	Reduction site	Active	1	RAD, ORG, INORG, METALS	CARBC;IC
54-012(b)	54	90 SWMU	Reduction site	Active	4	ORG, INORG, METALS	CARBC;IC
54-013(a)	54	A SWMU	Decontamination facility	Active	56	RAD, ORG, INORG, METALS, PET	rec NFA
54-013(b)	54	90 SWMU	Decontamination facility	Active	56	RAD, ORG, INORG, METALS, PET	CARBC;IC
54-014(a)	54	90 SWMU	Disposal shafts	Active	438	RAD, ORG, INORG, METALS, PB	IS;IC
54-014(b)	54	90 SWMU	Disposal pit	Active	28000	RAD, ORG, INORG, METALS	IS;IC
54-014(c)	54	90 SWMU	Disposal shafts	Active	227	RAD, ORG, INORG, METALS	IS;IC
54-014(d)	54	90 SWMU	Collection site	Active	8316	RAD, ORG, INORG, METALS	IS;IC

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PRS Information for OU # 1148

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
54-014(misc)	54	88 SWMU	Naterial disposal area	Active	0		IS;IC
54-015(a)	54	B SWMU	Storage area	Active	22	RAD, ORG, INORG, METALS	CARBC;IC
54-015(b)	54	90 SWMU	Storage area	Active	5	RAD, ORG, INORG, METALS	CARBC;IC
54-015(c)	54	90 SWMU	Storage area	Active	4016	ORG, INORG, METALS	CARBC;IC
54-015(d)	54	90 SWMU	Storage area	Active	1931	ORG, INORG, METALS	CARBC;IC
54-015(e)	54	90 SWMU	Storage area	Active	4016	ORG, INORG, METALS	CARBC;IC
54-015(f)	54	90 SWMU	Storage area	Active	2273	ORG, INORG, METALS	CARBC;IC
54-015(g)	54	90 SWMU	Storage area	Active	44	RAD, ORG, INORG, METALS	rec NFA
54-015(h)	54	88 SWMU	Packaging site	Active	59	ORG, INORG, METALS	rec NFA
54-015(i)	54	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS	rec NFA
54-015(j)	54	90 SWMU	Storage area	Active	267	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
54-015(k)	54	90 SWMU	Storage area	Active	574	RAD, ORG, INORG, METALS	CARBC;IC
54-016(a)	54	90 SWMU	Sump	Active	13	RAD, ORG, INORG, METALS	rec NFA
54-016(b)	54	90 SWMU	Sump	Active	1	RAD, ORG, INORG, METALS	CARBC;IC
54-017	54	90 SWMU	Disposal pits	Inactive	107713	RAD, ORG, INORG, METALS, ASBESTOS	CARBC;IC
54-017(misc)	54	88 SWMU	Material disposal area	Active	0		IS;IC

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PRS Information for OU # 1148

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
54-018	54	90 SWMU	Disposal pits	Active	104987	RAD, ORG, INORG, METALS, PCB	CARBC;IC
54-019	54	90 SWMU	Disposal shafts	Inactive	318	RAD, ORG, INORG, METALS, PET	CARBC;IC
54-019(misc)	54	88 SWMU	Material disposal area	Active	0		IS;IC
54-020	54	90 SWMU	Disposal shafts	Active	1435	RAD, ORG, INORG, METALS, PCB, PET	CARBC;IC
54-020(misc)	54	88 SWMU	material disposal area	Active	0		IS;IC
54-021	54	90 SWMU	Aboveground tank	Inactive	3	ORG, INORG, METALS, PET	rec NFA
54-022	54	90 SWMU	Transformer	Decommission	3	ORG, INORG, METALS, PCB	rec NFA
C-54-001	54	AOC	Sump and outfall	Active	0		rec NFA

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PRS Information for OU # 1154

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
57-001(a)	57	88 SWMU	Surface impoundment	Decommission	89	ORG, INORG, METALS	CARBC;IC
57-001(b)	57	88 SWMU	Surface impoundment	Decommission	2500	ORG, INORG, METALS	CARBC;IC
57-001(c)	57	88 SWMU	Surface impoundment	Decommission	89	ORG, INORG, METALS	CARBC;IC
57-002	57	88 SWMU	Landfill	Active	6667	ORG, INORG, METALS	CARBC;IC
57-003	57	88 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
57-004(a)	57	88 SWMU	Surface impoundment	Active	2500	ORG, INORG, METALS	CARBC;IC
57-004(b)	57	90 SWMU	Surface impoundment	Active	356	ORG, INORG, METALS	CARBC;IC
57-005	57	88 SWMU	Filter system	Active	1	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1157

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
8-001(a)	8	88 SWMU	Buildings	Unknown	19	HE, ORG, INORG, METALS, SOLV	CARBC;IC
8-001(b)	8	88 SWMU	Buildings	Unknown	4	HE, ORG, INORG, METALS, SOLV	CARBC;IC
8-002	8	A SWMU	Firing site	Inactive	185	RAD, HE, ORG, INORG, METALS	CARBC;IC
8-003(a)	8	B SWMU	Septic system	Inactive	13	HE, ORG, INORG, METALS, PHOCHEM	CARBC;IC
8-003(b)	8	B SWMU	Septic system	Inactive	2	ORG, INORG, METALS	CARBC;IC
8-003(c)	8	B SWMU	Septic system	Inactive	2	HE, ORG, INORG, METALS, PHOCHEM	CARBC;IC
8-004(a)	8	A SWMU	Sump	Inactive	1	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
8-004(b)	8	A SWMU	Sump	Inactive	1	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
8-004(c)	8	A SWMU	Sump	Inactive	16	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
8-004(d)	8	A SWMU	sump	Inactive	1	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
8-005	8	88 SWMU	Storage area	Inactive	3	ORG, INORG, METALS	CARBC;IC
8-006(a)	8	A SWMU	Landfill	Inactive	356	RAD, HE, ORG, INORG, METALS	CARBC;IC
8-006(b)	8	A SWMU	Landfill	Inactive	74	RAD, HE, ORG, INORG, METALS	CARBC;IC
8-007	8	B SWMU	Silver recovery unit	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
8-008(a)	8	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PCB, PET	CARBC;IC
8-008(b)	8	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PCB, PET	CARBC;IC

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PRS Information for OU # 1157

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
8-008(c)	8	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PCB, PET	CARBC;IC
8-008(d)	8	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PCB, PET	CARBC;IC
8-009(a)	8	90 SWMU	Drain line and outfall	Active	20	ORG, INORG, METALS	CARBC;IC
8-009(b)	8	90 SWMU	Drain line	Active	1	ORG, INORG, METALS	CARBC;IC
8-009(c)	8	90 SWMU	Storm drainage and outfall	Active	13	ORG, INORG, METALS, PHOCHEM	CARBC;IC
8-009(d)	8	90 SWMU	Drain line	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
8-009(e)	8	90 SWMU	Outfall	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
8-010(a)	8	90 SWMU	Storage area	Active	224	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
8-010(b)	8	90 SWMU	Storage area	Active	144	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
8-010(c)	8	90 SWMU	Storage area	active	17	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
8-011(a)	8	90 SWMU	Underground tank	Decommission	11	ORG, INORG, METALS, PET	CARBC;IC
8-011(b)	8	90 SWMU	Underground tank	Decommission	11	ORG, INORG, METALS, PET	CARBC;IC
C-8-001	8	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-8-002	8	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-8-003	8	AOC	Building	Removed	0		CARBC;IC
C-8-004	8	AOC	Building	Removed	0		CARBC;IC
C-8-005	8	AOC	Building	Removed	0		CARBC;IC

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PRS Information for OU # 1157

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-8-006	8	AOC	Building	Removed	0		CARBC;IC
C-8-007	8	AOC	Building	Removed	0		CARBC;IC
C-8-008	8	AOC	Building	Removed	0		CARBC;IC
C-8-009	8	AOC	Building	Removed	0		CARBC;IC
C-8-010	8	AOC	Building	Removed	0		CARBC;IC
C-8-011	8	AOC	Building	Removed	0		CARBC;IC
C-8-012	8	AOC	Building	Removed	0		CARBC;IC
C-8-013	8	AOC	Building	Removed	0		CARBC;IC
C-8-014	8	AOC	Laboratory	Active	0		CARBC;IC
C-8-015	8	AOC	Building	Active	0		CARBC;IC
C-8-016	8	AOC	Building	Active	0		CARBC;IC
C-8-017	8	AOC	Storage area	Active	0		CARBC;IC
C-8-018	8	AOC	Building	Active	0		CARBC;IC
C-8-019	8	AOC	Building	Active	0		CARBC;IC
C-8-020	8	AOC	Landfill	Inactive	370	RAD, ORG, INORG, METALS	CARBC;IC
9-001(a)	9	88 SWMU	Firing site	Decommission	24	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-001(b)	9	88 SWMU	Firing site	Decommission	36	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-001(c)	9	88 SWMU	Firing site	Decommission	43	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-001(d)	9	88 SWMU	Firing site	Decommission	37	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-002	9	88 SWMU	Disposal pit and burn site	Decommission	89	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1157

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
9-003(a)	9	A SWMU	Sump	Decommission	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-003(b)	9	A SWMU	Sump	Decommission	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-003(c)	9	A SWMU	Sump	Decommission	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-003(d)	9	A SWMU	Sump	Decommission	7	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-003(e)	9	A SWMU	Sump	Decommission	3	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-003(f)	9	A SWMU	Sump	Decommission	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-003(g)	9	90 SWMU	Sump	Decommission	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-003(h)	9	90 SWMU	Sump	Decommission	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-003(i)	9	90 SWMU	Sump	Decommission	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-004(a)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(b)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(c)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(d)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(e)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(f)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(g)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC

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PRS Information for OU # 1157

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
9-004(h)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(i)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(j)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(k)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(l)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(m)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(n)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-004(o)	9	A SWMU	Sump	Active	7	HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-005(a)	9	A SWMU	Septic system	Inactive	8	RAD,HE,ORG,INORG,METALS ,PHOCHEM	CARBC;IC
9-005(b)	9	A SWMU	Septic system	Active	10	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-005(c)	9	A SWMU	Septic system	Inactive	8	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-005(d)	9	A SWMU	Septic system	Inactive	20	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-005(e)	9	A SWMU	Septic system	Active	6	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-005(f)	9	A SWMU	Septic system	Active	8	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-005(g)	9	A SWMU	Septic system	Active	4	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-005(h)	9	A SWMU	Septic system	Active	2	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC

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PRS Information for OU # 1157

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
9-006	9	A SWMU	Septic system	Decommission	5	RAD,HE,ORG,INORG,METAL, SOLV,PHOCHEM	CARBC;IC
9-007	9	A SWMU	Sump	Inactive	4	HE, ORG, INORG, METALS	CARBC;IC
9-008(a)	9	90 SWMU	Surface impoundment	Inactive	1944	ORG, INORG, METALS, SOLV	CARBC;IC
9-008(b)	9	B SWMU	Surface impoundment	Inactive	217	ORG, INORG, METALS	CARBC;IC
9-009	9	A SWMU	Surface impoundment	Active	627	ORG, INORG, METALS, SOLV, PHOCHEM	CARBC;IC
9-010(a)	9	88 SWMU	Storage area	Unknown	7	HE, ORG, INORG, METALS	CARBC;IC
9-010(b)	9	90 SWMU	Storage area	Unknown	13	HE, ORG, INORG, METALS	CARBC;IC
9-010(c)	9	90 SWMU	Storage area	Unknown	13	HE, ORG, INORG, METALS	CARBC;IC
9-011(a)	9	88 SWMU	Storage area	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-011(b)	9	88 SWMU	Storage area	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-011(c)	9	88 SWMU	Storage area	Active	1	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
9-012	9	88 SWMU	Disposal pit	Inactive	1111	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-013	9	B SWMU	Material disposal area	Inactive	576	RAD,HE,ORG,INORG,METALS ,ASBESTOS	IS;IC
9-014	9	88 SWMU	Firing site	Decommission	70	HE, ORG, INORG, METALS	CARBC;IC
9-015	9	88 SWMU	Manhole	Decommission	1881	RAD, HE, ORG, INORG, METALS	CARBC;IC
9-016	9	90 SWMU	Underground tank	Decommission	74	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1157

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-9-001	9	AOC	Outfall	Active	370	ORG, INORG, METALS	CARBC;IC
C-9-002	9	AOC	Buildings	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-9-003	9	AOC	Buildings	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-9-004	9	AOC	Building	Active	0		CARBC;IC
C-9-005	9	AOC	Building	Removed	370	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-9-006	9	AOC	Buildings	Removed	1852	HE, ORG, INORG, METALS	CARBC;IC
C-9-007	9	AOC	Building	Removed	1111	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-9-008	9	AOC	Underground tank	Removed	74	ORG, INORG, METALS, PET	CARBC;IC
C-9-009	9	AOC	Non-intentional release area	Inactive	4	ORG, INORG, METALS, PET	CARBC;IC
C-9-010	9	AOC	Burn site	Unknown	37	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-9-011	9	AOC	Burn site	Unknown	37	RAD, HE, ORG, INORG, METALS	CARBC;IC
69-001	69	88 SWMU	Incinerator	Inactive	1852	ORG, INORG, METALS	CARBC;IC
69-002(a)	69	90 SWMU	Septic system	Active	43	ORG, INORG, METALS, SOLV	CARBC;IC
69-002(b)	69	90 SWMU	Septic system	Active	6	ORG, INORG, METALS, SOLV	CARBC;IC

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PRS Information for OU # 1079

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
10-001(a)	10	A SWMU	Firing site	Decommission	162963	RAD, HE, ORG, INORG, METALS	CARBC;IC
10-001(b)	10	A SWMU	Firing site	Decommission	162963	RAD, HE, ORG, INORG, METALS	CARBC;IC
10-001(c)	10	A SWMU	Firing site	Decommission	162963	RAD, HE, ORG, INORG, METALS	CARBC;IC
10-001(d)	10	A SWMU	Firing site	Decommission	162963	RAD, HE, ORG, INORG, METALS	CARBC;IC
10-001(e)	10	90 SWMU	Firing site	Decommission	162963	RAD, HE, ORG, INORG, METALS	rec NFA
10-002(a)	10	A SWMU	Disposal pit	Decommission	30	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-002(b)	10	A SWMU	Disposal pit	Decommission	56	RAD, ORG, INORG, METALS	CARBC;IC
10-003(a)	10	B SWMU	Disposal pit	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(b)	10	B SWMU	Disposal pit	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(c)	10	B SWMU	Disposal pit	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(d)	10	88 SWMU	Disposal pit	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(e)	10	88 SWMU	Disposal pit	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(f)	10	88 SWMU	Disposal pit	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(g)	10	B SWMU	Manhole	Decommission	4	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(h)	10	B SWMU	Manhole	Decommission	4	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(i)	10	B SWMU	Tank	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
10-003(j)	10	90 SWMU	Tank	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(k)	10	90 SWMU	Tank	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(l)	10	90 SWMU	Tank	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(m)	10	90 SWMU	Waste line	Decommission	2	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(n)	10	90 SWMU	Leach field	Decommission	19	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-003(o)	10	90 SWMU	Leach field	Decommission	1	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-004(a)	10	A SWMU	Septic system	Decommission	50	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-004(b)	10	A SWMU	Septic system	Decommission	17	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
10-005	10	88 SWMU	Surface disposal	Decommission	4	RAD, ORG, INORG, METALS	CARBC;IC
10-006	10	B SWMU	Burn site	Inactive	481	RAD, HE, ORG, INORG, METALS	rec NFA
10-007	10	88 SWMU	Landfill	Inactive	7407	ORG, INORG, METALS	CARBC;IC
31-001	31	A SWMU	Septic system	Decommission	78	ORG, INORG, METALS	CARBC;IC
C-31-001	31	AOC	Buildings	Removed	2222	RAD, HE, ORG, INORG, METALS	rec NFA
32-001	32	88 SWMU	Incinerator	Decommission	1	RAD, ORG, INORG, METALS	CARBC;IC
32-002(a)	32	A SWMU	Septic tank	Inactive	16	RAD, ORG, INORG, METALS	CARBC;IC
32-002(b)	32	A SWMU	Septic tank	Inactive	23	RAD, ORG, INORG, METALS, SOLV	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-32-001	32	AOC	Buildings	Removed	2222	RAD, HE, ORG, INORG, METALS	rec NFA
45-001	45	88 SWMU	Waste water treatment facility	Decommission	26	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
45-002	45	88 SWMU	Decontamination facility	Decommission	2	RAD, ORG, INORG, METALS, PET	CARBC;IC
45-003	45	88 SWMU	Waste lines	Decommission	3058	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
45-004	45	90 SWMU	Outfalls	Inactive	12	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
C-45-001	45	AOC	Generator site	Removed	111	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1082

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
11-001(a)	11	A SWMU	Firing site	Inactive	77	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-001(b)	11	A SWMU	Firing site	Inactive	77	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-001(c)	11	A SWMU	Firing site	Inactive	77	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-002	11	A SWMU	Burn site	Active	19	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-003(a)	11	88 SWMU	Mortar impact area	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
11-003(b)	11	88 SWMU	Firing range	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
11-004(a)	11	B SWMU	Drop tower	Active	392003	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-004(b)	11	B SWMU	Drop tower	Active	392003	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-004(c)	11	B SWMU	Drop tower	Active	392003	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-004(d)	11	B SWMU	Drop tower	Active	392003	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-004(e)	11	B SWMU	Drop tower	Active	392003	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-004(f)	11	88 SWMU	Drop tower	Active	392003	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-005(a)	11	B SWMU	Septic system	Active	3	HE, ORG, INORG, METALS, PHOCHEM	CARBC;IC
11-005(b)	11	B SWMU	Septic system	Active	2	HE, ORG, INORG, METALS	CARBC;IC
11-005(c)	11	90 SWMU	Septic system	Active	1	HE, ORG, INORG, METALS	CARBC;IC
11-006(a)	11	B SWMU	Sump	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1082

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
11-006(b)	11	B SWMU	Sump	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-006(c)	11	B SWMU	Sump	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-006(d)	11	B SWMU	Sump	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-007	11	A SWMU	Surface disposal	Inactive	139	RAD, ORG, INORG, METALS	CARBC;IC
11-008	11	88 SWMU	Surface disposal	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
11-009	11	A SWMU	Material disposal area	Active	22	HE, ORG, INORG, METALS	CARBC;IC
11-010(a)	11	88 SWMU	Container storage	Active	74	HE, ORG, INORG, METALS	CARBC;IC
11-010(b)	11	88 SWMU	Container storage	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
11-011(a)	11	90 SWMU	Outfall	Inactive	185	HE, ORG, INORG, METALS	CARBC;IC
11-011(b)	11	90 SWMU	Drain line and outfall	Active	1	HE, ORG, INORG, METALS	CARBC;IC
11-011(c)	11	90 SWMU	Outfall	Active	1	HE, ORG, INORG, METALS	CARBC;IC
11-011(d)	11	90 SWMU	Drain line	Active	2	HE, ORG, INORG, METALS	CARBC;IC
11-012(a)	11	90 SWMU	Building	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
11-012(b)	11	90 SWMU	Building	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
11-012(c)	11	90 SWMU	Building	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
11-012(d)	11	90 SWMU	Building	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-11-001	11	AOC	Laboratory	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-11-002	11	AOC	Laboratory	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-11-003	11	AOC	One-time release site	Inactive	15	RAD, ORG, INORG, METALS	CARBC;IC
13-001	13	88 SWMU	Firing site	Decommission	7272	RAD, HE, ORG, INORG, METALS	CARBC;IC
13-002	13	A SWMU	Landfill	Decommission	46	RAD, HE, ORG, INORG, METALS	CARBC;IC
13-003(a)	13	88 SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
13-003(b)	13	88 SWMU	Septic system	Decommission	56	ORG, INORG, METALS	CARBC;IC
13-004	13	B SWMU	Disposal pit	Inactive	185	RAD, ORG, INORG, METALS	CARBC;IC
16-001(a)	16	88 SWMU	Tank	Inactive	1	ORG, INORG, METALS, SOLV	CARBC;IC
16-001(b)	16	B SWMU	Dry wells	Inactive	1	ORG, INORG, METALS, SOLV	CARBC;IC
16-001(c)	16	B SWMU	Tank	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
16-001(d)	16	B SWMU	Dry well	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
16-001(e)	16	B SWMU	Dry well	Inactive	4	ORG, INORG, METALS, SOLV	CARBC;IC
16-003(a)	16	A SWMU	Sump	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-003(b)	16	A SWMU	Sump	Active	1	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-003(c)	16	A SWMU	Sump	Active	1	HE, ORG, INORG, METALS, SOLV	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-003(d)	16	A SWMU	Sump	Active	2	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-003(e)	16	A SWMU	Sump	Active	2	HE, ORG, INORG, METALS	CARBC;IC
16-003(f)	16	A SWMU	Sump	Active	2	HE, ORG, INORG, METALS	CARBC;IC
16-003(g)	16	A SWMU	Sump	Active	2	HE, ORG, INORG, METALS	CARBC;IC
16-003(h)	16	A SWMU	Sump	Active	1	HE, ORG, INORG, METALS	CARBC;IC
16-003(i)	16	A SWMU	Sump	Active	1	HE, ORG, INORG, METALS	CARBC;IC
16-003(j)	16	A SWMU	Sump	Active	1	HE, ORG, INORG, METALS	CARBC;IC
16-003(k)	16	A SWMU	Sump	Active	10	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-003(l)	16	A SWMU	Sump	Active	2	HE, ORG, INORG, METALS	CARBC;IC
16-003(m)	16	A SWMU	Sump	Active	2	HE, ORG, INORG, METALS	CARBC;IC
16-003(n)	16	A SWMU	Sump	Active	1	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-003(o)	16	A SWMU	Sump	Active	3	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-003(p)	16	90 SWMU	Sump	Active	1	HE, ORG, INORG, METALS	CARBC;IC
16-003(q)	16	90 SWMU	Sump	Active	1	HE, ORG, INORG, METALS	CARBC;IC
16-004(a)	16	A SWMU	Waste water treatment facility	Active	12	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
16-004(b)	16	A SWMU	Waste water treatment facility	Active	46	RAD, ORG, INORG, METALS, SOLV	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-004(c)	16	A SWMU	Waste water treatment facility	Active	6	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
16-004(d)	16	A SWMU	Waste water treatment facility	Active	9	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
16-004(e)	16	A SWMU	Waste water treatment facility	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
16-004(f)	16	A SWMU	Waste water treatment facility	Active	9	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
16-005(a)	16	88 SWMU	Septic system	Decommission	10	ORG, INORG, METALS	CARBC;IC
16-005(b)	16	88 SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
16-005(c)	16	88 SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
16-005(d)	16	88 SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
16-005(e)	16	88 SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
16-005(f)	16	88 SWMU	Septic system	Decommission	3	HE, ORG, INORG, METALS	CARBC;IC
16-005(g)	16	88 SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
16-005(h)	16	88 SWMU	Septic system	Decommission	1	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-005(i)	16	88 SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
16-005(j)	16	88 SWMU	Septic system	Decommission	2	ORG, INORG, METALS, SOLV, PHOCHEM	CARBC;IC
16-005(k)	16	88 SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
16-005(l)	16	88 SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-005(m)	16	88 SWMU	Septic system	Decommission	1	HE, ORG, INORG, METALS	CARBC;IC
16-005(n)	16	B SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
16-005(o)	16	B SWMU	Septic system	Decommission	1	ORG, INORG, METALS	CARBC;IC
16-006(a)	16	B SWMU	Septic system	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-006(b)	16	88 SWMU	Septic system	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-006(c)	16	B SWMU	Septic system	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-006(d)	16	B SWMU	Septic system	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-006(e)	16	B SMWU	Septic system	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-006(f)	16	B SWMU	Septic system	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-006(g)	16	88 SWMU	Septic system	Inactive	30	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-006(h)	16	88 SWMU	Septic system	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-006(i)	16	90 SWMU	Septic system	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-007(a)	16	B SWMU	Surface impoundment	Decommission	376	HE, ORG, INORG, METALS	CARBC;IC
16-007(b)	16	90 SWMU	Surface impoundment	Decommission	3	HE, ORG, INORG, METALS	CARBC;IC
16-008(a)	16	A SWMU	Surface impoundment	Inactive	463	RAD,HE,ORG,INORG,METALS ,SOLV	CARBC;IC
16-008(b)	16	B SWMU	Surface impoundment	Inactive	39	RAD,HE,ORG,INORG,METALS ,SOLV	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-009(a)	16	A SWMU	Burn site	Decommission	185	HE, ORG, INORG, METALS	CARBC;IC
16-010(a)	16	A SWMU	Burn site	Active	185	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(b)	16	A SWMU	Burn site	Active	185	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(c)	16	A SWMU	Burn site	Active	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(d)	16	A SWMU	Burn site	Active	7	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(e)	16	A SWMU	Burn site	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(f)	16	A SWMU	Burn site	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(g)	16	A SWMU	Waste water treatment facility	Active	7	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(h)	16	A SWMU	Burn site	Active	9	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(i)	16	A SWMU	Burn site	Inactive	3	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(j)	16	A SWMU	Burn site	Active	3	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(k)	16	A SWMU	Burn site	Inactive	9	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(l)	16	A SWMU	Burn site	Inactive	9	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(m)	16	A SWMU	Burn site	Inactive	9	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-010(n)	16	90 SWMU	Burn site	Inactive	9	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-011	16	88 SWMU	Incinerators	Active/ina	21	HE, ORG, INORG, METALS, SOLV, PET	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-012(a)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(a2)	16	90 SWMU	Container storage	Active	46	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-012(b)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(c)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(d)	16	A SWMU	Satellite storage	Active	1	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-012(e)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(f)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(g)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(h)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(i)	16	A SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
16-012(j)	16	A SWMU	Satellite storage	Active	1	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-012(k)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(l)	16	A SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
16-012(m)	16	A SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
16-012(n)	16	A SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
16-012(o)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-012(p)	16	A SWMU	Container storage	Active	46	HE, ORG, INORG, METALS	CARBC;IC
16-012(q)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(r)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(s)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(t)	16	A SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
16-012(u)	16	A SWMU	Satellite storage	Active	1	HE, ORG, INORG, METALS	CARBC;IC
16-012(v)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(w)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(x)	16	A SWMU	Satellite storage	Active	1	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-012(y)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-012(z)	16	A SWMU	Container storage	Active	7	HE, ORG, INORG, METALS	CARBC;IC
16-013	16	A SWMU	Container storage	Decommission	7	ORG, INORG, METALS, SOLV	CARBC;IC
16-015(a)	16	88 SWMU	Operational facility	Decommission	2	HE, ORG, INORG, METALS	CARBC;IC
16-015(b)	16	88 SWMU	Operational facility	Decommission	2	HE, ORG, INORG, METALS	CARBC;IC
16-015(c)	16	88 SWMU	Operational facility	Decommission	2	HE, ORG, INORG, METALS	CARBC;IC
16-015(d)	16	88 SWMU	Operational facility	Decommission	1	HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-016(a)	16	B SWMU	Landfill	Inactive	37	HE, ORG, INORG, METALS	CARBC;IC
16-016(b)	16	B SWMU	Landfill	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
16-016(c)	16	B SWMU	Landfill	Inactive	28	HE, ORG, INORG, METALS	CARBC;IC
16-016(d)	16	90 SWMU	Landfill	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-016(e)	16	90 SWMU	Landfill	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-016(f)	16	90 SWMU	Landfill	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-016(g)	16	90 SWMU	Landfill	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
16-017	16	88 SWMU	Buildings	Inactive	926	HE, ORG, INORG, METALS	CARBC;IC
16-018	16	B SWMU	Material disposal area	Inactive	216509	RAD, HE, ORG, INORG, METALS	IS;IC
16-019	16	B SWMU	Material disposal area	Inactive	73245	RAD, HE, ORG, INORG, METALS	IS;IC
16-020	16	B SWMU	Silver recovery unit	Active	137	ORG, INORG, METALS, PHOCHEM	CARBC;IC
16-021(a)	16	B SWMU	Systematic release site	Active	1	ORG, INORG, METALS	CARBC;IC
16-021(b)	16	90 SWMU	Systematic leak	Inactive	1	ORG, INORG, METALS, PET	CARBC;IC
16-021(c)	16	90 SWMU	Operational facility	Active	0		CARBC;IC
16-022(a)	16	88 SWMU	Underground tank	Inactive	1	ORG, INORG, METALS, PET	CARBC;IC
16-022(b)	16	90 SWMU	Underground tank	Inactive	1	ORG, INORG, METALS, PET	CARBC;IC

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16-023(b)	16	88 SWMU	Incinerator	Decommission	25	HE, ORG, INORG, METALS	CARBC;IC
16-024(a)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(b)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(c)	16	90 SWMU	Operational facility	Inactive	11	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(d)	16	90 SWMU	Operational facility	Inactive	11	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(e)	16	90 SWMU	Operational facility	Inactive	23	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(f)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(g)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(h)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(i)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(j)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(k)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(l)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(m)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(n)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(o)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-024(p)	16	90 SWMU	Operational facility	Inactive	11	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(q)	16	90 SWMU	Operational facility	Inactive	11	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(r)	16	90 SWMU	Operational facility	Inactive	19	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(s)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(t)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(u)	16	90 SWMU	Operational facility	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-024(v)	16	90 SWMU	Operational facility	Inactive	7	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(a)	16	90 SWMU	Building	Inactive	67	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(a2)	16	90 SWMU	Building	Inactive	42	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(b)	16	90 SWMU	Building	Inactive	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(b2)	16	90 SWMU	Building	Inactive	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(c)	16	90 SWMU	Building	Inactive	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(c2)	16	90 SWMU	Building	Inactive	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(d)	16	90 SWMU	Building	Inactive	17	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(d2)	16	90 SWMU	Building	Inactive	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(e)	16	90 SWMU	Building	Inactive	23	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-025(e2)	16	90 SWMU	Building	Inactive	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(f)	16	90 SWMU	Building	Inactive	28	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(f2)	16	90 SWMU	Building	Inactive	35	HE, ORG, INORG, METALS	CARBC;IC
16-025(g)	16	90 SWMU	Building	Inactive	9	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(g2)	16	90 SWMU	Building	Inactive	35	HE, ORG, INORG, METALS	CARBC;IC
16-025(h)	16	90 SWMU	Building	Inactive	9	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(h2)	16	90 SWMU	Building	Inactive	35	HE, ORG, INORG, METALS	CARBC;IC
16-025(i)	16	90 SWMU	Building	Inactive	11	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(j)	16	90 SWMU	Building	Inactive	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(k)	16	90 SWMU	Building	Inactive	23	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(l)	16	90 SWMU	Building	Inactive	139	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(m)	16	90 SWMU	Building	Inactive	7	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(n)	16	90 SWMU	Building	Inactive	7	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(o)	16	90 SWMU	Building	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(p)	16	90 SWMU	Building	Inactive	46	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(q)	16	90 SWMU	Building	Inactive	46	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-025(r)	16	90 SWMU	Building	Inactive	46	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(s)	16	90 SWMU	Building	Inactive	11	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(t)	16	90 SWMU	Building	Inactive	93	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(u)	16	90 SWMU	Building	Inactive	556	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(v)	16	90 SWMU	Building	Inactive	46	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(w)	16	90 SWMU	Building	Inactive	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(x)	16	90 SWMU	Building	Inactive	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(y)	16	90 SWMU	Building	Inactive	46	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-025(z)	16	90 SWMU	Building	Inactive	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(a)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
16-026(a2)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(b)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-026(b2)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(c)	16	90 SWMU	Outfall	Inactive	2	RAD,HE,ORG,INORG,METALS ,SOLV	CARBC;IC
16-026(c2)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
16-026(d)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-026(d2)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(e)	16	90 SWMU	Outfall	Inactive	2	RAD,HE,ORG,INORG,METALS ,SOLV	CARBC;IC
16-026(e2)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(f)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(f2)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(g)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS, PET	CARBC;IC
16-026(g2)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(h)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(h2)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(i)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(i2)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(j)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(j2)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(k)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(k2)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(l)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-026(m)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(n)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(o)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(p)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(q)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(r)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS, PET	CARBC;IC
16-026(s)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS, SOLV, PET	CARBC;IC
16-026(t)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(u)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(v)	16	90 SWMU	Outfall	Inactive	2	RAD,HE,ORG,INORG,METALS ,SOLV	CARBC;IC
16-026(w)	16	90 SWMU	Outfall	Inactive	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
16-026(x)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(y)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-026(z)	16	90 SWMU	Outfall	Inactive	2	RAD, ORG, INORG, METALS	CARBC;IC
16-027(a)	16	90 SWMU	Transformer	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
16-027(b)	16	90 SWMU	Transformer	Active	1	ORG, INORG, METALS, PCB	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-027(c)	16	90 SWMU	Transformer	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
16-027(d)	16	90 SWMU	Transformer	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
16-028(a)	16	90 SWMU	Outfall	Active	9	HE, ORG, INORG, METALS	CARBC;IC
16-028(b)	16	90 SWMU	Outfall	Active	9	ORG, INORG, METALS, SOLV	CARBC;IC
16-028(c)	16	90 SWMU	Outfall	Active	9	ORG, INORG, METALS	CARBC;IC
16-028(d)	16	90 SWMU	Outfall	Active	9	ORG, INORG, METALS	CARBC;IC
16-028(e)	16	90 SWMU	Outfall	Active	9	ORG, INORG, METALS	CARBC;IC
16-029(a)	16	A SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(a2)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(b)	16	A SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(b2)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(c)	16	A SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(c2)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(d)	16	A SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(d2)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(e)	16	A SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-029(e2)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(f)	16	A SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(f2)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(g)	16	A SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(g2)	16	90 SWMU	Sump	Inactive	3	HE, ORG, INORG, METALS	CARBC;IC
16-029(h)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(h2)	16	88 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(i)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(j)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(k)	16	90 SWMU	Sump	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
16-029(l)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(m)	16	90 SWMU	Sump	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
16-029(n)	16	90 SWMU	Sump	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
16-029(o)	16	90 SWMU	Sump	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
16-029(p)	16	90 SWMU	Sump	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
16-029(q)	16	90 SWMU	Sump	Inactive	3	HE, ORG, INORG, METALS	CARBC;IC

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16-029(r)	16	90 SWMU	Sump	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
16-029(s)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(t)	16	90 SWMU	Sump	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
16-029(u)	16	90 SWMU	Sump	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
16-029(v)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(w)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(x)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(y)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-029(z)	16	90 SWMU	Sump	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
16-030(a)	16	90 SWMU	Outfall	Active	3	HE, ORG, INORG, METALS, SOLV	CARBC;IC
16-030(b)	16	90 SWMU	Outfall	Active	3	ORG, INORG, METALS	CARBC;IC
16-030(c)	16	90 SWMU	Outfall	Active	6	ORG, INORG, METALS	CARBC;IC
16-030(d)	16	90 SWMU	Outfall	Active	3	HE, ORG, INORG, METALS	CARBC;IC
16-030(e)	16	90 SWMU	Outfall	Active	3	ORG, INORG, METALS	CARBC;IC
16-030(f)	16	90 SWMU	Outfall	Active	3	ORG, INORG, METALS	CARBC;IC
16-030(g)	16	90 SWMU	Outfall	Active	3	ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-030(h)	16	90 SWMU	Outfall	Active	3	ORG, INORG, METALS	CARBC;IC
16-031(a)	16	90 SWMU	Outfall	Inactive	5	ORG, INORG, METALS	CARBC;IC
16-031(b)	16	90 SWMU	Outfall	Inactive	5	ORG, INORG, METALS	CARBC;IC
16-031(c)	16	90 SWMU	Outfall	Inactive	5	HE, ORG, INORG, METALS	CARBC;IC
16-031(d)	16	90 SWMU	Outfall	Inactive	5	ORG, INORG, METALS	CARBC;IC
16-031(e)	16	90 SWMU	Outfall	Inactive	5	ORG, INORG, METALS	CARBC;IC
16-031(f)	16	90 SWMU	Outfall	Inactive	5	ORG, INORG, METALS	CARBC;IC
16-031(g)	16	90 SWMU	Outfall	Inactive	5	ORG, INORG, METALS	CARBC;IC
16-031(h)	16	90 SWMU	Outfall	Inactive	5	ORG, INORG, METALS	CARBC;IC
16-032(a)	16	90 SWMU	Sump	Decommission	1	HE, ORG, INORG, METALS	CARBC;IC
16-032(b)	16	90 SWMU	Sump	Decommission	1	HE, ORG, INORG, METALS	CARBC;IC
16-032(c)	16	90 SWMU	Sump	Decommission	1	HE, ORG, INORG, METALS	CARBC;IC
16-032(d)	16	90 SWMU	Sump	Decommission	1	HE, ORG, INORG, METALS	CARBC;IC
16-032(e)	16	90 SWMU	Sump	Decommission	1	HE, ORG, INORG, METALS	CARBC;IC
16-033(a)	16	90 SWMU	Underground tank	Decommission	1	ORG, INORG, METALS, PET	CARBC;IC
16-033(b)	16	90 SWMU	Underground tank	Decommission	1	ORG, INORG, METALS, PET	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-033(c)	16	90 SWMU	Underground tank	Decommission	7	ORG, INORG, METALS, PET	CARBC;IC
16-033(e)	16	90 SWMU	Underground tank	Decommission	1	ORG, INORG, METALS, PET	CARBC;IC
16-033(f)	16	90 SWMU	Underground tank	Decommission	1	ORG, INORG, METALS, PET	CARBC;IC
16-033(g)	16	90 SWMU	Underground tank	Decommission	1	ORG, INORG, METALS, PET	CARBC;IC
16-033(h)	16	90 SWMU	Underground tank	Decommission	1	ORG, INORG, METALS, PET	CARBC;IC
16-033(i)	16	90 SWMU	Underground tank	Decommission	1	ORG, INORG, METALS, PET	CARBC;IC
16-033(j)	16	90 SWMU	Underground tank	Decommission	1	ORG, INORG, METALS, PET	CARBC;IC
16-034(a)	16	90 SWMU	Laboratory	Inactive	28	HE, ORG, INORG, METALS	CARBC;IC
16-034(b)	16	90 SWMU	Laboratory	Inactive	133	HE, ORG, INORG, METALS	CARBC;IC
16-034(c)	16	90 SWMU	Building	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-034(d)	16	90 SWMU	Building	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-034(e)	16	90 SWMU	Building	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
16-034(f)	16	90 SWMU	Building	Inactive	28	HE, ORG, INORG, METALS	CARBC;IC
16-034(g)	16	90 SWMU	Building	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-034(h)	16	90 SWMU	Building	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-034(i)	16	90 SWMU	Building	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
16-034(j)	16	90 SWMU	Building	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-034(k)	16	90 SWMU	Building	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-034(l)	16	90 SWMU	Building	Inactive	4	HE, ORG, INORG, METALS	CARBC;IC
16-034(m)	16	90 SWMU	Laboratory	Inactive	4	HE, ORG, INORG, METALS	CARBC;IC
16-034(n)	16	90 SWMU	Laboratory	Inactive	7	HE, ORG, INORG, METALS	CARBC;IC
16-034(o)	16	90 SWMU	Laboratory	Inactive	65	HE, ORG, INORG, METALS	CARBC;IC
16-034(p)	16	90 SWMU	Laboratory	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
16-035	16	90 SWMU	Building	Inactive	145	ORG, INORG, METALS	CARBC;IC
16-036	16	90 SWMU	Building	Inactive/a	93	HE, ORG, INORG, METALS	CARBC;IC
16-037	16	90 SWMU	Aboveground tank	Active	1	ORG, INORG, METALS	CARBC;IC
C-16-001	16	AOC	Building	Removed	0		CARBC;IC
C-16-002	16	AOC	Building	Removed	0		CARBC;IC
C-16-003	16	AOC	Septic system	Removed	0		CARBC;IC
C-16-004	16	AOC	Building	Removed	0		CARBC;IC
C-16-005	16	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-16-006	16	AOC	Building	Removed	0		CARBC;IC
C-16-007	16	AOC	Building	Removed	0		CARBC;IC
C-16-008	16	AOC	Building	Removed	0		CARBC;IC
C-16-009	16	AOC	Building	Removed	0		CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-16-010	16	AOC	Building	Removed	0		CARBC;IC
C-16-011	16	AOC	Building	Removed	0		CARBC;IC
C-16-012	16	AOC	Building	Removed	0		CARBC;IC
C-16-013	16	AOC	Storage area	Removed	0		CARBC;IC
C-16-014	16	AOC	Building	Removed	0		CARBC;IC
C-16-015	16	AOC	Building	Removed	0		CARBC;IC
C-16-016	16	AOC	Building	Removed	0		CARBC;IC
C-16-017	16	AOC	Building	Removed	0		CARBC;IC
C-16-018	16	AOC	Aboveground tank	Removed	0		CARBC;IC
C-16-019	16	AOC	Building	Removed	0		CARBC;IC
C-16-020	16	AOC	Building	Removed	0		CARBC;IC
C-16-021	16	AOC	Building	Removed	0		CARBC;IC
C-16-022	16	AOC	Building	Removed	0		CARBC;IC
C-16-023	16	AOC	Warehouse	Removed	0		CARBC;IC
C-16-024	16	AOC	Building	Removed	0		CARBC;IC
C-16-025	16	AOC	Building	Removed	0		CARBC;IC
C-16-026	16	AOC	Building	Removed	0		CARBC;IC
C-16-027	16	AOC	Building	Removed	0		CARBC;IC
C-16-028	16	AOC	Building	Removed	0		CARBC;IC
C-16-029	16	AOC	Building	Removed	0		CARBC;IC
C-16-030	16	AOC	Building	Removed	0		CARBC;IC
C-16-031	16	AOC	Building	Removed	0		CARBC;IC
C-16-032	16	AOC	Building	Removed	0		CARBC;IC

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PRS Information for OU # 1082

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-16-033	16	AOC	Warehouse	Removed	0		CARBC;IC
C-16-034	16	AOC	Aboveground tank	Removed	0		CARBC;IC
C-16-035	16	AOC	Aboveground tank	Removed	0		CARBC;IC
C-16-036	16	AOC	Septic system	Removed	0		CARBC;IC
C-16-037	16	AOC	Storage area	Removed	0		CARBC;IC
C-16-038	16	AOC	Storage area	Removed	0		CARBC;IC
C-16-039	16	AOC	Building	Removed	0		CARBC;IC
C-16-040	16	AOC	Building	Removed	0		CARBC,IC
C-16-041	16	AOC	Building	Removed	0		CARBC;IC
C-16-042	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-043	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-044	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-045	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-046	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-047	16	AOC	Transport area	Removed	0		CARBC;IC
C-16-048	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-049	16	AOC	Building	Removed	0		CARBC;IC
C-16-050	16	AOC	Building	Removed	0		CARBC;IC
C-16-051	16	AOC	Transport area	Removed	0		CARBC;IC

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PRS Information for OU # 1082

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-16-052	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-053	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-054	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-055	16	AOC	Generation area	Removed	0		CARBC;IC
C-16-056	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-057	16	AOC	Manhole	Removed	0		CARBC;IC
C-16-058	16	AOC	Transport area	Removed	0		CARBC;IC
C-16-059	16	AOC	Generation area	Removed	0		CARBC;IC
C-16-060	16	AOC	Building	Removed	74	RAD, ORG, INORG, METALS	CARBC;IC
C-16-061	16	AOC	Building	Removed	1	HE, ORG, INORG, METALS	CARBC;IC
C-16-062	16	AOC	Generation area	Removed	0		CARBC;IC
C-16-063	16	AOC	Generation area	Removed	0		CARBC;IC
C-16-064	16	AOC	Storage area	Removed	370	ORG, INORG, METALS	CARBC;IC
C-16-065	16	AOC	Storage area	Inactive	370	ORG, INORG, METALS	CARBC;IC
C-16-066	16	AOC	Storage area	Inactive	37	ORG, INORG, METALS	CARBC;IC
C-16-067	16	AOC	Storage area	Removed	370	ORG, INORG, METALS	CARBC;IC
C-16-068	16	AOC	Building	Removed	370	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1082

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-16-069	16	AOC	Building	Removed	0		CARBC;IC
C-16-070	16	AOC	Underground tank	Inactive	37	ORG, INORG, METALS, PET	CARBC;IC
C-16-071	16	AOC	One-time spill	Removed	0		CARBC;IC
C-16-072	16	AOC	Tank	Unknown	37	ORG, INORG, METALS, PET	CARBC;IC
C-16-073	16	AOC	Underground tank	Active	37	ORG, INORG, METALS, PET	CARBC;IC
C-16-074	16	AOC	Storage area	Inactive	37	ORG, INORG, METALS	CARBC;IC
25-001	25	88 SWMU	Disposal pit	Decommission	3	HE, ORG, INORG, METALS	CARBC;IC
C-25-001	25	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
37-001	37	88 SWMU	Septic system	Inactive	266	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1085

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
12-001(a)	12	A SWMU	Firing site	Inactive	889	RAD, HE, ORG, INORG, METALS	CARBC;IC
12-001(b)	12	A SWMU	Firing site	Inactive	7	RAD, HE, ORG, INORG, METALS	CARBC;IC
12-002	12	88 SWMU	Burn site	Inactive	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
12-003	12	88 SWMU	Storage area	Inactive	1	ORG, INORG, METALS	CARBC;IC
12-004(a)	12	88 SWMU	Operational facility	Inactive	335	RAD, HE, ORG, INORG, METALS	CARBC;IC
12-004(b)	12	88 SWMU	Operational facility	Inactive	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-12-001	12	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-12-002	12	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-12-003	12	AOC	Building	Decommission	37	HE, ORG, INORG, METALS	CARBC;IC
C-12-004	12	AOC	Building	Decommission	0		CARBC;IC
C-12-005	12	AOC	Building	Decommission	0		CARBC;IC
C-12-006	12	AOC	Building	Inactive	370	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-001(a)	14	88 SWMU	Firing site	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-001(b)	14	88 SWMU	Firing site	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-001(c)	14	88 SWMU	Firing site	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-001(d)	14	88 SWMU	Firing site	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-001(e)	14	88 SWMU	Firing site	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1085

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
14-001(f)	14	88 SWMU	Firing site	Active	2	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-001(g)	14	88 SWMU	Firing site	Active	3	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-002(a)	14	A SWMU	Firing site	Decommission	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-002(b)	14	A SWMU	Firing site	Decommission	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-002(c)	14	A SWMU	Firing site	Decommission	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-002(d)	14	A SWMU	Firing site	Decommission	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-002(e)	14	A SWMU	Firing site	Decommission	12	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-002(f)	14	A SWMU	Firing site	Decommission	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-003	14	88 SWMU	Burn site	Inactive	36	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-004(a)	14	88 SWMU	Storage area	Active	1	HE, ORG, INORG, METALS	CARBC;IC
14-004(b)	14	A SWMU	Storage area	Active	1	HE, ORG, INORG, METALS	CARBC;IC
14-004(c)	14	88 SWMU	Storage area	Active	4	HE, ORG, INORG, METALS	CARBC;IC
14-005	14	A SWMU	Incinerator	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-006	14	88 SWMU	Sump	Active	7	HE, ORG, INORG, METALS	CARBC;IC
14-007	14	A SWMU	Septic system	Active	3	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-008	14	88 SWMU	Landfill and surface disposal	Inactive	1389	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1085

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
14-009	14	88 SWMU	Surface disposal	Active	74	RAD, HE, ORG, INORG, METALS	CARBC;IC
14-010	14	90 SWMU	Sump	Decommission	7	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-14-001	14	AOC	Building	Decommission	37	HE, ORG, INORG, METALS	CARBC;IC
C-14-002	14	AOC	Building	Removed	370	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-14-003	14	AOC	Building	Removed	370	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-14-004	14	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-14-005	14	AOC	Building	Removed	370	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-14-006	14	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-14-007	14	AOC	Building	Removed	370	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-14-008	14	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-14-009	14	AOC	Building	Decommission	37	HE, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1086

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
15-001	15	88 SWMU	Surface disposal	Active	93	RAD, INORG, METALS	CARBC;IC
15-002	15	B SWMU	Disposal pit and burn site	Inactive	4	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-003	15	A SWMU	Firing site	Active	7	HE, ORG, INORG, METALS	CARBC;IC
15-004(a)	15	88 SWMU	Firing site	Inactive	2327	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-004(b)	15	88 SWMU	Firing site	Inactive	2327	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-004(c)	15	A SWMU	Firing site	Inactive	2327	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-004(d)	15	88 SWMU	Firing site	Inactive	582	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-004(e)	15	88 SWMU	Firing site	Inactive	582	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-004(f)	15	88 SWMU	Firing site	Inactive	21685	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-004(g)	15	88 SWMU	Firing site	Inactive	5236	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-004(h)	15	88 SWMU	Firing site	Inactive	5236	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-004(i)	15	90 SWMU	Firing site	Inactive	5236	HE, ORG, INORG, METALS	CARBC;IC
15-005(a)	15	88 SWMU	Storage area	Active	1	METALS	CARBC;IC
15-005(b)	15	88 SWMU	Storage area	Active	1	HE	CARBC;IC
15-005(c)	15	88 SWMU	Storage area	Active	1	HE	CARBC;IC
15-005(d)	15	90 SWMU	Storage area	Active	1	METALS	CARBC;IC

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PRS Information for OU # 1086

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
15-006(a)	15	B SWMU	Firing site	Active	24850	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-006(b)	15	B SWMU	Firing site	Active	9308	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-006(c)	15	B SWMU	Firing site	Active	5236	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-006(d)	15	B SWMU	Firing site	Active	5236	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-006(e)	15	90 SWMU	Firing site	Active	463	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-007(a)	15	A SWMU	Landfill	Inactive	2420	RAD, HE, METALS	CARBC;IC
15-007(b)	15	A SWMU	Landfill	Inactive	16133	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-007(c)	15	A SWMU	Shaft	Inactive	124	HE, METALS	CARBC;IC
15-007(d)	15	A SWMU	Shaft	Inactive	124	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-008(a)	15	B SWMU	Surface disposal	Inactive	2778	RAD, METALS	CARBC;IC
15-008(b)	15	B SWMU	Surface disposal	Inactive	926	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-008(c)	15	B SWMU	Surface disposal	Inactive	463	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-008(d)	15	B SWMU	Surface disposal	Inactive	116	ORG, INORG, METALS	CARBC;IC
15-008(e)	15	90 SWMU	Surface disposal	Inactive	15	ORG, INORG, METALS	CARBC;IC
15-008(f)	15	90 SWMU	Surface disposal	Inactive	370	ORG, INORG, METALS	CARBC;IC
15-008(g)	15	90 SWMU	Surface disposal	Inactive	370	RAD, ORG, INORG, METALS	CARBC;IC
15-009(a)	15	B SWMU	Septic system	Active	6	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1086

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
15-009(b)	15	B SWMU	Septic system	Active	7	ORG, INORG, METALS	CARBC;IC
15-009(c)	15	88 SWMU	Septic system	Active	142	ORG, INORG, METALS	CARBC;IC
15-009(d)	15	88 SWMU	Septic system	Active	21	ORG, INORG, METALS	CARBC;IC
15-009(e)	15	88 SWMU	Septic system	Active	142	ORG, INORG, METALS	CARBC;IC
15-009(f)	15	88 SWMU	Septic system	Active	355	ORG, INORG, METALS	CARBC;IC
15-009(g)	15	88 SWMU	Septic system	Active	96	ORG, INORG, METALS,	CARBC;IC
15-009(h)	15	88 SWMU	Septic system	Active	117	ORG, INORG, METALS	CARBC;IC
15-009(i)	15	88 SWMU	Septic system	Active	145	ORG, INORG, METALS	CARBC;IC
15-009(j)	15	88 SWMU	Septic system	Active	145	ORG, INORG, METALS	CARBC;IC
15-009(k)	15	90 SWMU	Septic system	Active	141	ORG, INORG, METALS	CARBC;IC
15-010(a)	15	A SWMU	Septic system	Inactive	115	RAD, ORG, INORG, METALS	CARBC;IC
15-010(b)	15	A SWMU	Septic system	Inactive	118	RAD, HE, ORG, INORG, METALS	CARBC;IC
15-010(c)	15	B SWMU	Septic system	Inactive	112	ORG, INORG, METALS	CARBC;IC
15-011(a)	15	A SWMU	Sump	Inactive	142	HE, ORG, INORG, METALS	CARBC;IC
15-011(b)	15	A SWMU	Dry well	Inactive	23	ORG, INORG, METALS, ACIDS, SOLV	CARBC;IC
15-011(c)	15	A SWMU	Sump	Inactive	142	ORG, INORG, METALS, ACIDS	CARBC;IC

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PRS Information for OU # 1086

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
15-012(a)	15	B SWMU	Surface disposal	Inactive	9	RAD, ORG, INORG, METALS	CARBC;IC
15-012(b)	15	90 SWMU	Surface disposal	Inactive	9	RAD, ORG, INORG, METALS	CARBC;IC
15-013(a)	15	90 SWMU	Underground tank	Removed	5	ORG, PET	CARBC;IC
15-013(b)	15	90 SWMU	Underground tank	Removed	5	ORG, PET	CARBC;IC
15-014(a)	15	90 SWMU	Outfall	Active	940	ORG, INORG, METALS	CARBC;IC
15-014(b)	15	90 SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(c)	15	90 SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(d)	15	90 SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(e)	15	90 SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(f)	15	90 SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(g)	15	90 SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(h)	15	90 SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(i)	15	B SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(j)	15	B SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(k)	15	B SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
15-014(l)	15	B SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1086

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
15-014(m)	15	B SWMU	Outfall	Active	94	ORG, INORG, METALS	CARBC;IC
C-15-001	15	AOC	Surface disposal	Inactive	19	RAD, ORG, INORG, METALS	CARBC;IC
C-15-002	15	AOC	Surface disposal	Inactive	19	RAD, HE, METALS	CARBC;IC
C-15-003	15	AOC	Surface disposal	Inactive	19	ORG, INORG, METALS	CARBC;IC
C-15-004	15	AOC	Transformers	Removed	0	PCB	CARBC;IC
C-15-005	15	AOC	Laboratory and building	Removed	370	RAD, ORG, INORG, METALS	CARBC;IC
C-15-006	15	AOC	Building	Removed	370	ORG, INORG, METALS	CARBC;IC
C-15-007	15	AOC	Non-intentional release area	Inactive	4	ORG, INORG, METALS	CARBC;IC
C-15-008	15	AOC	Non-intentional release area	Inactive	0		CARBC;IC
C-15-009	15	AOC	Underground tank	Inactive	74	ORG, PET	CARBC;IC
C-15-010	15	AOC	Underground tank	Removed	74	ORG, PET	CARBC;IC
C-15-011	15	AOC	Underground tank	Inactive	37	ORG, PET	CARBC;IC
C-15-012	15	AOC	Underground tank	Active	0		CARBC;IC
C-15-013	15	AOC	Underground tank	Inactive	0		CARBC;IC

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PRS Information for OU # 1093

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
18-001(a)	18	B SWMU	Septic system	Active	533	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
18-001(b)	18	90 SWMU	Sewer lines	Active	64	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
18-001(c)	18	90 SWMU	Sump	Active	1	RAD, ORG, INORG, METALS, PHOCHEM	CARBC;IC
18-002(a)	18	A SWMU	Firing site	Inactive	2315	RAD, HE, ORG, INORG, METALS	CARBC;IC
18-002(b)	18	A SWMU	Firing site	Decommission	93	RAD, HE, ORG, INORG, METALS	CARBC;IC
18-002(c)	18	88 SWMU	Drop tower	Inactive	93	RAD, HE, ORG, INORG, METALS	CARBC;IC
18-003(a)	18	B SWMU	Septic system	Active	46	RAD, ORG, INORG, METALS	CARBC;IC
18-003(b)	18	B SWMU	Septic system	Active	46	RAD, ORG, INORG, METALS	CARBC;IC
18-003(c)	18	B SWMU	Septic system	Active	54	RAD, ORG, INORG, METALS	CARBC;IC
18-003(d)	18	B SWMU	Septic system	Active	49	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
18-003(e)	18	B SWMU	Septic system	Inactive	65	ORG, INORG, METALS, SOLV	CARBC;IC
18-003(f)	18	B SWMU	Septic system	Inactive	65	ORG, INORG, METALS, SOLV	CARBC;IC
18-003(g)	18	B SWMU	Septic system	Inactive	49	ORG, INORG, METALS, SOLV	CARBC;IC
18-003(h)	18	B SWMU	Septic system	Inactive	19	ORG, INORG, METALS, SOLV	CARBC;IC
18-004(a)	18	88 SWMU	Waste lines	Decommission	1	RAD, ORG, INORG, METALS, SOLV, ACID	CARBC;IC
18-004(b)	18	A SWMU	Disposal pit	Decommission	1	RAD, ORG, INORG, METALS, SOLV, ACID	CARBC;IC

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PRS Information for OU # 1093

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
18-005(a)	18	A SWMU	Storage area	Inactive	23	RAD, ORG, INORG, METALS	CARBC;IC
18-005(b)	18	90 SWMU	Storage area	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
18-005(c)	18	90 SWMU	Storage area	Inactive	23	HE, ORG, INORG, METALS	CARBC;IC
18-006	18	88 SWMU	Waste line	Inactive	1	RAD, ORG, INORG, METALS	CARBC;IC
18-007	18	A SWMU	Landfill	Inactive	174	RAD, HE, ORG, INORG, METALS	CARBC;IC
18-008	18	90 SWMU	Underground tank	Decommission	1	ORG, INORG, METALS	CARBC;IC
18-009(a)	18	90 SWMU	Transformer	Decommission	3	ORG, INORG, METALS, PCB	CARBC;IC
18-009(b)	18	90 SWMU	Transformer	Decommission	1	ORG, INORG, METALS, PCB	CARBC;IC
18-009(c)	18	90 SWMU	Transformer	Decommission	3	ORG, INORG, METALS, PCB	CARBC;IC
18-009(d)	18	90 SWMU	Transformer	Decommission	3	ORG, INORG, METALS, PCB	CARBC;IC
18-009(e)	18	90 SWMU	Transformer	Decommission	44	ORG, INORG, METALS, PCB	CARBC;IC
18-010(a)	18	90 SWMU	Outfall	Active	39	RAD, ORG, INORG, METALS	CARBC;IC
18-010(b)	18	90 SWMU	Outfall	Active	39	RAD, ORG, INORG, METALS	CARBC;IC
18-010(c)	18	90 SWMU	Outfall	Active	39	RAD, ORG, INORG, METALS	CARBC;IC
18-010(d)	18	90 SWMU	Outfall	Active	39	RAD, ORG, INORG, METALS	CARBC;IC
18-010(e)	18	90 SWMU	Outfall	Active	40	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1093

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
18-010(f)	18	90 SWMU	Outfall	Active	39	RAD, ORG, INORG, METALS	CARBC;IC
18-011	18	90 SWMU	Building	Decommission	33	HE, ORG, INORG, METALS	CARBC;IC
18-012(a)	18	90 SWMU	Waste line and storm drainage	Active	37	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
18-012(b)	18	90 SWMU	Sumps and outfall	Active	37	RAD, ORG, INORG, METALS	CARBC;IC
18-012(c)	18	90 SWMU	Sump and drain lines	Active	1	RAD, ORG, INORG, METALS	CARBC;IC
18-012(d)	18	90 SWMU	Drain line	Active	1	ORG, INORG, METALS	CARBC;IC
C-18-001	18	AOC	Laboratory	Unknown	370	ORG, INORG, METALS, PHOCHEM	CARBC;IC
C-18-002	18	AOC	Building	Removed	0		CARBC;IC
C-18-003	18	AOC	Storage area	Unknown	370	RAD, ORG, INORG, METALS	CARBC;IC
27-001	27	A SWMU	Landfill	Inactive	370	RAD, ORG, INORG, METALS	CARBC;IC
27-002	27	A SWMU	Firing site	Inactive	11574	RAD, HE, ORG, INORG, METALS, PB, BE	CARBC;IC
27-003	27	A SWMU	Mortar impact area	Inactive	5556	HE, ORG, INORG, METALS	CARBC;IC
27-004	27	90 SWMU	Building	Inactive	15	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1098

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
2-001	2	88 SWMU	Burn site	Inactive	46	ORG, INORG, METALS	CARBC;IC
2-002	2	88 SWMU	Storage area	Inactive	25	ORG, INORG, METALS, PET, PCB	CARBC;IC
2-003(a)	2	88 SWMU	Reactor facility	Decommission	8	RAD, ORG, INORG, METALS	CARBC;IC
2-003(b)	2	88 SWMU	Reactor facility	Decommission	5	RAD, ORG, INORG, METALS	CARBC;IC
2-003(c)	2	88 SWMU	Reactor facility	Decommission	1	RAD, ORG, INORG, METALS	CARBC;IC
2-003(d)	2	88 SWMU	Reactor facility	Decommission	3	RAD, ORG, INORG, METALS	CARBC;IC
2-003(e)	2	88 SWMU	Reactor facility	Decommission	2	RAD, ORG, INORG, METALS	CARBC;IC
2-004(a)	2	88 SWMU	Reactor facility	Active	3	RAD, ORG, INORG, METALS	CARBC;IC
2-004(b)	2	88 SWMU	Reactor facility	Active	6	RAD, ORG, INORG, METALS	CARBC;IC
2-004(c)	2	88 SWMU	Reactor facility	Active	6	RAD, ORG, INORG, METALS	CARBC;IC
2-004(d)	2	88 SWMU	Reactor facility	Active	6	RAD, ORG, INORG, METALS	CARBC;IC
2-004(e)	2	88 SWMU	Reactor facility	Active	21	RAD, ORG, INORG, METALS	CARBC;IC
2-004(f)	2	88 SWMU	Reactor facility	Active	13	RAD, ORG, INORG, METALS	CARBC;IC
2-004(g)	2	90 SWMU	Aboveground tank	Active	2	RAD, ORG, INORG, METALS	CARBC;IC
2-005	2	B SWMU	Systematic leak	Inactive	741	ORG, INORG, METALS	CARBC;IC
2-006(a)	2	88 SWMU	Waste line	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC

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PRS Information for OU # 1098

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
2-006(b)	2	90 SWMU	Waste line	Active	167	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
2-006(c)	2	90 SWMU	Waste line	Active	167	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
2-006(d)	2	90 SWMU	Waste line	Active	167	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
2-006(e)	2	90 SWMU	Waste line	Active	167	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
2-007	2	A SWMU	Septic system	Decommission	15	RAD, ORG, INORG, METALS	CARBC;IC
2-008(a)	2	B SWMU	Outfall	Inactive	19	RAD, ORG, INORG, METALS	CARBC;IC
2-008(b)	2	90 SWMU	Outfall	Inactive	19	ORG, INORG, METALS, PHOCHEM	CARBC;IC
2-008(c)	2	90 SWMU	Outfall	Active	19	ORG, INORG, METALS	CARBC;IC
2-009(a)	2	A SWMU	Non-intentional release area	Inactive	449	RAD, ORG, INORG, METALS	CARBC;IC
2-009(b)	2	A SWMU	Non-intentional release area	Inactive	148	RAD, ORG, INORG, METALS	CARBC;IC
2-009(c)	2	A SWMU	Non-intentional release area	Inactive	208	RAD. ORG, INORG, METALS	CARBC;IC
2-009(d)	2	90 SWMU	Non-intentional release area	Inactive	93	RAD, ORG, INORG, METALS	CARBC;IC
2-010	2	88 SWMU	Building	Inactive/d	94	RAD, ORG, INORG, METALS, SOLV, ACID	CARBC;IC
2-011(a)	2	90 SWMU	Storm drainage and outfall	Active	228	RAD, ORG, INORG, METALS	CARBC;IC
2-011(b)	2	90 SWMU	Storm drainage and outfall	Active	1	RAD, ORG, INORG, METALS	CARBC;IC
2-011(c)	2	90 SWMU	Storm drainage and outfall	Active	1	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1098

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
2-011(d)	2	90 SWMU	Storm drainage and outfall	Active	37	ORG, INORG, METALS, SOLV	CARBC;IC
2-011(e)	2	90 SWMU	Storm drainage and outfall	Active	37	ORG, INORG, METALS, SOLV	CARBC;IC
2-012	2	90 SWMU	Underground tank	Inactive	2	ORG, INORG, METALS, PET	CARBC;IC
2-013	2	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
41-001	41	B SWMU	Septic system	Inactive	2	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
41-002(a)	41	A SWMU	Waste water treatment facility	Active	25	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
41-002(b)	41	A SWMU	Waste water treatment facility	Active	42	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
41-002(c)	41	A SWMU	Waste water treatment facility	Active	17	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
41-003	41	90 SWMU	Sump	Active	1	ORG, INORG, METALS	CARBC;IC
41-004	41	90 SWMU	Container storage	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
C-41-001	41	AOC	Sump	Unknown	0		CARBC;IC
C-41-002	41	AOC	Underground tank	Active	0		CARBC;IC
C-41-003	41	AOC	Underground tank	Unknown	0		CARBC;IC
C-41-004	41	AOC	Storm drainages	Unknown	370	ORG, INORG, METALS	CARBC;IC
C-41-005	41	AOC	Underground tank	Unknown	10	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1100

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
20-001(a)	20	A SWMU	Landfill	Inactive	1778	RAD, HE, ORG, INORG, METALS	CARBC;IC
20-001(b)	20	A SWMU	Landfill	Inactive	5185	RAD, HE, ORG, INORG, METALS	CARBC;IC
20-001(c)	20	A SWMU	Landfill	ilactive	1333	RAD, HE, ORG, INORG, METALS	CARBC;IC
20-002	20	A SWMU	Firing site	Decommission	296	RAD, HE, ORG, INORG, METALS	CARBC;IC
20-003(a)	20	A SWMU	Firing site	Decommission	20	RAD, HE, ORG, INORG, METALS	CARBC;IC
20-003(b)	20	88 SWMU	Firing site	Decommission	20	RAD, HE, ORG, INORG, METALS	CARBC;IC
20-003(c)	20	88 SWMU	Firing site	Decommission	20	RAD, HE, ORG, INORG, METALS	CARBC;IC
20-003(d)	20	88 SWMU	Firing site	Decommission	20	RAD, HE, ORG, INORG, METALS	CARBC;IC
20-004	20	88 SWMU	Septic system	Active	3	ORG, INORG, METALS, SOLV	CARBC;IC
20-005	20	88 SWMU	Septic system	Decommission	2	ORG, INORG, METALS, SOLV	CARBC;IC
C-20-001	20	AOC	Storage area	Removed	370	RAD, ORG, INORG, METALS	CARBC;IC
C-20-002	20	AOC	Storage area	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-20-003	20	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
53-001(a)	53	A SWMU	Storage area	Active	48	RAD, ORG, INORG, METALS, SOLV, ACID	CARBC;IC
53-001(b)	53	A SWMU	Storage area	Active	48	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(c)	53	88 SWMU	Storage area	Active	6	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1100

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
53-001(d)	53	88 SWMU	Storage area	Active	24	RAD, ORG, INORG, METALS, PET	CARBC;IC
53-001(e)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(f)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(g)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(h)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(i)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, PHOCHEM	CARBC;IC
53-001(j)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(k)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(l)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(m)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(n)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-001(o)	53	90 SWMU	Storage area	Active	1	RAD, ORG, INORG, METALS, PHOCHEM	CARBC;IC
53-002(a)	53	A SWMU	Disposal lagoon	Active	14974	RAD, ORG, INORG, METALS	CARBC;IC
53-002(b)	53	A SWMU	Disposal lagoon	Active	9733	RAD, ORG, INORG, METALS	CARBC;IC
53-003	53	88 SWMU	Septic tank	Active	2	ORG, INORG, METALS	CARBC;IC
53-004	53	88 SWMU	Operational facility	Active	23	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1100

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
53-005	53	A SWMU	Disposal pit	Decommission	5	ORG, INORG, METALS, PCB	CARBC;IC
53-006(a)	53	88 SWMU	Underground tank	Inactive	8	RAD, ORG, INORG, METALS	CARBC;IC
53-006(b)	53	A SWMU	Underground tank	Active	13	RAD, ROG, INORG, METALS, SOLV	CARBC;IC
53-006(c)	53	A SWMU	Underground tank	Active	13	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-006(d)	53	A SWMU	Underground tank	Active	20	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-006(e)	53	A SWMU	Underground tank	Active	20	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-006(f)	53	90 SWMU	Underground tank	Active	20	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
53-007(a)	53	A SWMU	Aboveground tank	Active	14	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-007(b)	53	A SWMU	Aboveground tank	Active	4	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
53-008	53	88 SWMU	Surface disposal	Active	120	RAD, ORG, INORG, METALS	CARBC;IC
53-009	53	88 SWMU	Aboveground tanks	Actove	3	ORG, INORG, METALS	CARBC;IC
53-010	53	90 SWMU	Container storage	Decommission	35	ORG, INORG, METALS	CARBC;IC
53-011(a)	53	90 SWMU	Transformer	Active	1	ORG, INORG, METALS, PCB, PET	CARBC;IC
53-011(b)	53	90 SWMU	Transformer	Active	1	ORG, INORG, METALS, PCB, PET	CARBC;IC
53-011(c)	53	90 SWMU	Transformer	Active	1	ORG, INORG, METALS, PCB, PET	CARBC;IC
53-011(d)	53	90 SWMU	Tranformer	Active	0		CARBC;IC

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PRS Information for OU # 1100

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
53-011(e)	53	90 SWMU	Transformer	Active	0		CARBC;IC
53-012(a)	53	90 SWMU	Outfall	Active	39	RAD, ORG, INORG, METALS	CARBC;IC
53-012(b)	53	90 SWMU	Outfall	Active	26	RAD, ORG, INORG, METALS	CARBC;IC
53-012(c)	53	90 SWMU	Outfall	Active	52	RAD, ORG, INORG, METALS	CARBC;IC
53-012(d)	53	90 SWMU	Outfall	Active	156	RAD, ORG, INORG, METALS	CARBC;IC
53-012(e)	53	90 SWMU	Outfall	Active	156	RAD, ORG, INORG, METALS	CARBC;IC
53-012(f)	53	90 SWMU	Outfall	Active	156	RAD, ORG, INORG, METALS	CARBC;IC
53-012(g)	53	90 SWMU	Outfall	Active	104	RAD, ORG, INORG, METALS	CARBC;IC
53-012(h)	53	90 SWMU	Outfall	Active	65	RAAD, ORG, INORG, METALS	CARBC;IC
C-53-001	53	AOC	Transformer	Active	0		CARBC;IC
C-53-002	53	AOC	Transformer	Active	0		CARBC;IC
C-53-003	53	AOC	Transformer	Active	0		CARBC;IC
C-53-004	53	AOC	Transformer	Active	0		CARBC;IC
C-53-005	53	AOC	Transformer	Active	0		CARBC;IC
C-53-006	53	AOC	Transformer	Active	0		CARBC;IC
C-53-007	53	AOC	Transformer	Active	0		CARBC;IC
C-53-008	53	AOC	Transformer	Active	0	PCB	CARBC;IC

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PRS Information for OU # 1100

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-53-009	53	AOC	Transformer	Active	0		CARBC;IC
C-53-010	53	AOC	Transformer	Active	0		CARBC;IC
C-53-011	53	AOC	Transformer	Active	0		CARBC;IC
C-53-012	53	AOC	Transformer	Active	0		CARBC;IC
C-53-013	53	AOC	Transformer	Active	0		CARBC;IC
C-53-014	53	AOC	Transformer	Active	0		CARBC;IC
C-53-015	53	AOC	Transformer	Active	0		CARBC;IC
C-53-016	53	AOC	Transformer	Active	0		CARBC;IC
C-53-017	53	AOC	One-time spill	Unknown	4	ORG, INORG, METALS, PCB	CARBC;IC
C-53-018	53	AOC	One-time spill	Removed	0		CARBC;IC
C-53-019	53	AOC	One-time spill	Unknown	1	ORG, INORG, METALS, PCB	CARBC;IC
72-001	72	88 SWMU	Firing range	Active	405	ORG, INORG, METALS, PCB	CARBC;IC
72-002	72	88 SWMU	Firing site	Inactive	2017	HE, ORG, INORG, METALS	CARBC;IC
72-003(a)	72	90 SWMU	Septic system	Active	936	ORG, INORG, METALS, SOLV	CARBC;IC
72-003(b)	72	90 SWMU	Septic system	Inactive	3	ORG, INORG, METALS, SOLV	CARBC;IC

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PRS Information for OU # 1106

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
21-001	21	88 SWMU	Container storage	Active	234	RAD, ORG, INORG, METALS	CARBC;IC
21-002(a)	21	A SWMU	Container storage	Inactive	0	ORG, INORG, METALS	CARBC;IC
21-002(b)	21	90 SWMU	Container storage	Inactive	80700	ORG, INORG, METALS, ACIDS	CARBC;IC
21-003	21	A SWMU	Container storage	Inactive	347	ORG, INORG, METALS, PCB, PET	CARBC;IC
21-004(a)	21	88 SWMU	Aboveground tank	Active	1	RAD, ORG, INORG, METALS	CARBC;IC
21-004(b)	21	88 SWMU	Aboveground tank	Active	25	RAD, ORG, INORG, METALS	CARBC;IC
21-004(c)	21	88 SWMU	Aboveground tank	Active	25	RAD, ORG, INORG, METALS	CARBC;IC
21-004(d)	21	90 SWMU	Outfall	Active	72	RAD, ORG, INORG, METALS	CARBC;IC
21-005	21	A SWMU	Disposal pit	Decommission	21	ORG, INORG, METALS, ACIDS	CARBC;IC
21-006(a)	21	B SWMU	Disposal pit	Inactive	242	RAD, ORG, INORG, METALS	CARBC;IC
21-006(b)	21	B SWMU	Disposal pit	Inactive	270	RAD, ORG, INORG, METALS	CARBC;IC
21-006(c)	21	B SWMU	Disposal pit	Inactive	242	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-006(d)	21	B SWMU	Disposal pit	Inactive	242	RAD, ORG, INORG, METALS	CARBC;IC
21-006(e)	21	90 SWMU	Disposal pit	Inactive	242	RAD, ORG, INORG, METALS	CARBC;IC
21-006(f)	21	90 SWMU	Disposal pit	Inactive	242	RAD, ORG, INORG, METALS	CARBC;IC
21-007	21	A SWMU	Incinerators	Decommission	540	RAD, ORG, INORG, METALS, PET	CARBC;IC

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PRS Information for OU # 1106

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
21-008	21	88 SWMU	Incinerator	Decommission	271	RAD, ORG, INORG, METALS	CARBC;IC
21-009	21	88 SWMU	Laboratory	Decommission	341	RAD, ORG, INORG, METALS	CARBC;IC
21-010(a)	21	B SWMU	Waste treatment facility	Decommission	5603	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-010(b)	21	B SWMU	Waste treatment facility	Decommission	7	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-010(c)	21	B SWMU	Waste treatment facility	Decommission	2	ORG, INORG, METALS, ACIDS	CARBC;IC
21-010(d)	21	B SWMU	Waste treatment facility	Decommission	2	ORG, INORG, METALS, ACIDS	CARBC;IC
21-010(e)	21	B SWMU	Waste treatment facility	Decommission	2	ORG, INORG, METALS	CARBC;IC
21-010(f)	21	B SWMU	Waste treatment facility	Decommission	6	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-010(g)	21	B SWMU	Waste treatment facility	Decommission	12	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-010(h)	21	B SWMU	Waste treatment facility	Decommission	3	ORG, INORG, METALS, ACIDS	CARBC;IC
21-011(a)	21	B SWMU	Waste treatment facility	Active	21511	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-011(b)	21	B SWMU	Sump	Active	34	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-011(c)	21	B SWMU	Tank	Active	20	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-011(d)	21	B SWMU	Aboveground tank	Active	75	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-011(e)	21	B SWMU	Aboveground tank	Active	75	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-011(f)	21	B SWMU	Aboveground tank	Active	75	RAD, ORG, INORG, METALS, SOLV	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
21-011(g)	21	B SWMU	Aboveground tank	Active	75	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-011(h)	21	90 SWMU	Aboveground tank	Active	11	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-011(i)	21	B SWMU	Aboveground tank	Active	5	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-011(j)	21	B SWMU	Aboveground tank	Active	4	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-012(a)	21	B SWMU	Dry well	Unknown	405	ORG, INORG, METALS	rec NFA
21-012(b)	21	90 SWMU	Dry well	Unknown	405	ORG, INORG, METALS	CARBC;IC
21-013(a)	21	A SWMU	Surface disposal	Inactive	4	RAD, ORG, INORG, METALS	CARBC;IC
21-013(b)	21	A SWMU	Surface disposal	Inactive	74	RAD, ORG, INORG, METALS	CARBC;IC
21-013(c)	21	A SWMU	Surface disposal	Inactive	1152	RAD, ORG, INORG, METALS	CARBC;IC
21-013(d)	21	90 SWMU	Surface disposal	Inactive	102	RAD, ORG, INORG, METALS	CARBC;IC
21-013(e)	21	90 SWMU	Surface disposal	Inactive	17130	RAD, ORG, INORG, METALS	CARBC;IC
21-013(f)	21	90 SWMU	Surface disposal	Inactive	1111	RAD, ORG, INORG, METALS	CARBC;IC
21-013(g)	21	90 SWMU	Surface disposal	Inactive	1	RAD, ORG, INORG, METALS	CARBC;IC
21-014	21	B SWMU	Material disposal area	Inactive	7007	RAD, ORG, INORG, METALS, SOLV	IS;IC
21-015	21	B SWMU	Material disposal area	Inactive	210473	RAD, ORG, INORG, METALS, SOLV	IS;IC
21-016(a)	21	B SWMU	Material disposal area	Inactive	69395	RAD, ORG, INORG, METALS, ACIDS	IS;IC

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PRS Information for OU # 1106

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
21-016(b)	21	B SWMU	Material disposal area	Inactive	1	RAD, ORG, INORG, METALS, ACIDS	IS;IC
21-016(c)	21	B SWMU	Material disposal area	Inactive	2566	RAD, ORG, INORG, METALS, ACIDS	IS;IC
21-017(a)	21	B SWMU	Material disposal area	Inactive	20186	RAD, ORG, INORG, METALS, PCB	IS;IC
21-017(b)	21	B SWMU	Material disposal area	Inactive	20186	RAD, ORG, INORG, METALS, PCB	IS;IC
21-017(c)	21	B SWMU	Material disposal area	Inactive	20186	RAD, ORG, INORG, METALS, PCB	IS;IC
21-018(a)	21	B SWMU	Material disposal area	Inactive	241939	RAD, ORG, INORG, METALS, SOLV	IS;IC
21-018(b)	21	B SWMU	Material disposal area	Inactive	3573	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
21-019(a)	21	88 SWMU	Filter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(b)	21	88 SWMU	Filter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(c)	21	88 SWMU	Filter system	Inactive	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(d)	21	88 SWMU	Filter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(e)	21	88 SWMU	Filter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(f)	21	88 SWMU	Filter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(g)	21	88 SWMU	Filter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(h)	21	88 SWMU	Ffilter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(i)	21	88 SWMU	Filter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
21-019(j)	21	88 SWMU	Filter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(k)	21	88 SWMU	Filter system	Inactive	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(l)	21	88 SWMU	Filter system	Inactive	40	RAD, ORG, INORG, METALS	CARBC;IC
21-019(m)	21	88 SWMU	Filter system	Active	40	RAD, ORG, INORG, METALS	CARBC;IC
21-020(a)	21	88 SWMU	Filter system	Decommission	7222	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-020(b)	21	88 SWMU	Filter system	Decommission	3889	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-021	21	A SWMU	Systematic release site	Active	59796	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-022(a)	21	A SWMU	Waste lines	Decommission	3	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-022(b)	21	A SWMU	Waste lines	Decommission	188	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-022(c)	21	A SWMU	Waste lines	Decommission	217	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-022(d)	21	A SWMU	Waste lines	Decommission	173	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-022(e)	21	A SWMU	Waste lines	Decommission	193	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-022(g)	21	A SWMU	Waste lines	Decommission	21	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-022(h)	21	A SWMU	Waste lines	Decommission	7	RAD, ROG, INORG, METALS, ACIDS	CARBC;IC
21-022(i)	21	90 SWMU	Sump	Decommission	9	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
21-022(j)	21	90 SWMU	Sump	Decommission	9	RAD, ROG, INORG, METALS, ACIDS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
21-023(a)	21	A SWMU	Septic system	Decommission	11	RAD, ORG, INORG, METALS	CARBC;IC
21-023(b)	21	A SWMU	Septic system	Decommission	4	RAD, ORG, INORG, METALS	CARBC;IC
21-023(c)	21	A SWMU	Septic system	Decommission	14	RAD, ORG, INORG, METALS	CARBC;IC
21-023(d)	21	A SWMU	Septic system	Decommission	4	RAD, ORG, INORG, METALS	CARBC;IC
21-024(a)	21	A SWMU	Septic system	Inactive	38	RAD, ORG, INORG, METALS	CARBC;IC
21-024(b)	21	A SWMU	Septic system	Inactive	9	RAD, ORG, INORG, METALS	CARBC;IC
21-024(c)	21	A SWMU	Septic system	Inactive	8	RAD, ORG, INORG, METALS	CARBC;IC
21-024(d)	21	A SWMU	Septic system	inactive	33	RAD, ORG, INORG, METALS	CARBC;IC
21-024(e)	21	A SWMU	Septic system	Inactive	14	RAD, ORG, INORG, METALS	CARBC;IC
21-024(f)	21	A SWMU	Septic system	Inactive	6	RAD, ORG, INORG, METALS	CARBC;IC
21-024(g)	21	A SWMU	Septic system	Inactive	33	RAD, ORG, INORG, METALS	CARBC;IC
21-024(h)	21	A SWMU	Septic system	Inactive	17	RAD, ORG, INORG, METALS	CARBC;IC
21-024(i)	21	A SWMU	Septic system	Inactive	16	RAD, ORG, INORG, METALS	CARBC;IC
21-024(j)	21	A SWMU	Septic system	Inactive	5	RAD, ORG, INORG, METALS	CARBC;IC
21-024(k)	21	A SWMU	Septic system	Inactive	18	RAD, ORG, INORG, METALS	CARBC;IC
21-024(l)	21	90 SWMU	Septic system	Inactive	1	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1106

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
21-024(m)	21	90 SWMU	Septic system	Inactive	1	RAD, ORG, INORG, METALS	CARBC;IC
21-024(n)	21	90 SWMU	Septic system	Inactive	1	RAD, ORG, INORG, METALS	CARBC;IC
21-024(o)	21	90 SWMU	Septic system	Inactive	1	RAD, ORG, INORG, METALS	CARBC;IC
21-025(a)	21	88 SWMU	Operational facility	Active	9	RAD, ORG, INORG, METALS	rec NFA
21-025(b)	21	88 SWMU	Operational facility	Active	9	RAD, ORG, INORG, METALS	rec NFA
21-026(a)	21	88 SWMU	Waste water treatment facility	Active	636	RAD, ORG, INORG, METALS	CARBC;IC
21-026(b)	21	88 SWMU	Waste water treatment facility	active	295	RAD, ORG, INORG, METALS	CARBC;IC
21-026(c)	21	88 SWMU	Waste water treatment facility	Active	2	RAD, ORG, INORG, METALS	CARBC;IC
21-027	21	88 SWMU	Drain lines and outfalls	Unknown	106	RAD, ORG, INORG, METALS	CARBC;IC
21-028(a)	21	88 SWMU	Container storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
21-028(b)	21	88 SWMU	Container storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
21-028(c)	21	88 SWMU	Container storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
21-028(d)	21	88 SWMU	Container storage	Active	1	RAD, ORG, INORG, METALS	CARBC;IC
21-028(e)	21	90 SWMU	Container storage	Active	1	ORG, INORG, METALS, SOLV	rec NFA
21-029	21	90 SWMU	Tanks	Decommission	7502	ORG, INORG, METALS, SOLV, PET	CARBC;IC
C-21-001	21	AOC	One-time spill	Removed	0		CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-21-002	21	AOC	Non-intentional release area	Removed	37	RAD, ORG, INORG, METALS	CARBC;IC
C-21-003	21	AOC	Non-intentional release area	Removed	37	RAD, ORG, INORG, METALS, ACIDS	CARBC;IC
C-21-004	21	AOC	Non-intentional release area	Removed	37	RAD, ORG, INORG, METALS	CARBC;IC
C-21-005	21	AOC	One-time release site	Removed	0		CARBC;IC
C-21-006	21	AOC	Non-intentional release area	Removed	37	RAD, ORG, INORG, METALS	CARBC;IC
C-21-007	21	AOC	Non-intentional release area	Active	0		CARBC;IC
C-21-008	21	AOC	One-time spill	Removed	37	RAD, ORG, INORG, METALS	CARBC;IC
C-21-009	21	AOC	One-time spill	Removed	0		CARBC;IC
C-21-010	21	AOC	Systematic leak	Removed	37	RAD, ORG, INORG, METALS	CARBC;IC
C-21-011	21	AOC	One-time spill	Removed	37	RAD, ORG, INORG, METALS	CARBC;IC
C-21-012	21	AOC	oNe-time spill	Removed	0		CARBC;IC
C-21-013	21	AOC	Disposal pit	Unknown	370	ORG, INORG, METALS	CARBC;IC
C-21-014	21	AOC	Warehouse	Active	0		CARBC;IC
C-21-015	21	AOC	Building	Removed	0		CARBC;IC
C-21-016	21	AOC	Storage area	Removed	0		CARBC;IC
C-21-017	21	AOC	Storage area	Removed	0		CARBC;IC
C-21-018	21	AOC	Storage area	Removed	0		CARBC;IC

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PRS Information for OU # 1106

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-21-019	21	AOC	Storage area	Removed	0		CARBC;IC
C-21-020	21	AOC	Storage area	Removed	0		CARBC;IC
C-21-021	21	AOC	Storage area	Removed	0		CARBC;IC
C-21-022	21	AOC	Laboratory	Removed	370	ORG, INORG, METALS	CARBC;IC
C-21-023	21	AOC	Laboratory	Removed	370	ORG, INORG, METALS	CARBC;IC
C-21-024	21	AOC	Warehouse	Removed	370	ORG, INORG, METALS	CARBC;IC
C-21-025	21	AOC	Building	Removed	370	ORG, INORG, METALS	CARBC;IC
C-21-026	21	AOC	Building	Removed	0		CARBC;IC
C-21-027	21	AOC	Machinery	Active	0		CARBC;IC
C-21-028	21	AOC	Tank	Removed	74	ORG, INORG, METALS, SOLV, PET	CARBC;IC
C-21-029	21	AOC	Aboveground tank	Removed	74	ORG, INORG, METALS, SOLV, PET	CARBC;IC
C-21-030	21	AOC	Aboveground tank	Removed	0		CARBC;IC
C-21-031	21	AOC	Tank	Unknown	0		CARBC;IC
C-21-032	21	AOC	Machinery and tanks	Active	0		CARBC;IC
C-21-033	21	AOC	One-time spill	Removed	0		CARBC;IC
C-21-034	21	AOC	Tank	Removed	0		CARBC;IC
C-21-035	21	AOC	Aboveground tank	Removed	0		CARBC;IC
C-21-036	21	AOC	Aboveground tank	Removed	0		CARBC;IC

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PRS Information for OU # 1106

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-21-037	21	AOC	Aboveground tank	Removed	0		CARBC;IC

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PRS Information for OU # 1111

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
6-001(a)	6	A SWMU	Septic system	Active	6	HE, ORG, INORG, METALS, SOLV	CARBC;IC
6-001(b)	6	A SWMU	Septic system	Active	5	HE, ORG, INORG, METALS, SOLV	CARBC;IC
6-002	6	A SWMU	Septic system	Decommission	6	HE, ORG, INORG, METALS	CARBC;IC
6-003(a)	6	88 SWMU	Firing site	Inactive	2327	RAD, HE, ORG, INORG, METALS	CARBC;IC
6-003(b)	6	88 SWMU	Firing site	Inactive	11	RAD, HE, ORG, INORG, METALS	CARBC;IC
6-003(c)	6	A SWMU	Firing site	Inactive	7	RAD, HE, ORG, INORG, METALS	CARBC;IC
6-003(d)	6	88 SWMU	Firing site	Inactive	101	HE, ORG, INORG, METALS	CARBC;IC
6-003(e)	6	88 SWMU	Firing site	Inactive	93	HE, ORG, INORG, METALS	CARBC;IC
6-004	6	88 SWMU	Sump	Inactive	11	HE, ORG, INORG, METALS	CARBC;IC
6-005	6	88 SWMU	Firing site	Decommission	96	RAD, HE, ORG, INORG, METALS	CARBC;IC
6-006	6	A SWMU	Storage area	Inactive	222	ORG, INORG, METALS, PCB, PET	CARBC;IC
6-007(a)	6	A SWMU	Material disposal area	Inactive	1222	RAD, HE, ORG, INORG, METALS	CARBC;IC
6-007(b)	6	A SWMU	Landfill	Inactive	622	RAD, HE, ORG, INORG, METALS	CARBC;IC
6-007(c)	6	A SWMU	Landfill	Inactive	8	RAD, HE, ORG, INORG, METALS	CARBC;IC
6-007(d)	6	A SWMU	Landfill	Inactive	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
6-007(e)	6	90 SWMU	Landfill	Inactive	44	RAD, HE, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1111

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
6-007(f)	6	90 SWMU	Surface disposal	Inactive	0		CARBC;IC
6-008	6	90 SWMU	Underground tank	Decommission	10	HE, ORG, INORG, METALS	CARBC;IC
C-6-001	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-002	6	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-6-003	6	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-6-004	6	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-6-005	6	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-6-006	6	AOC	Building	Removed	370	HE, ORG, INORG, METALS	CARBC;IC
C-6-007	6	AOC	Building	Removed	370	ORG, INORG, METALS	CARBC;IC
C-6-008	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-009	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-010	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-011	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-012	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-013	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-014	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
C-6-015	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-016	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-017	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-018	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-019	6	AOC	Building	Removed	37	HE, ORG, INORG, METALS	CARBC;IC
C-6-020	6	AOC	Building	Removed	370	ORG, INORG, METALS	CARBC;IC
C-6-021	6	AOC	Building	removed	37	HE, ORG, INORG, METALS	CARBC;IC
7-001(a)	7	A SWMU	Firing site	Decommission	105	RAD, HE, ORG, INORG, METALS	CARBC;IC
7-001(b)	7	A SWMU	Firing site	Decommission	105	RAD, HE, ORG, INORG, METALS	CARBC;IC
22-001	22	88 SWMU	Building	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
22-003(a)	22	88 SWMU	Satellite storage	Active/ina	1	ORG, INORG, METALS, SOLV, ACIDS	CARBC;IC
22-003(b)	22	90 SWMU	Satellite storage	Active	1	HE, ORG, INORG, METALS, SOLV	CARBC;IC
22-003(c)	22	90 SWMU	Satellite storage	Active	1	HE,ORG,INORG,METALS,SOLV,PHOCHEM	CARBC;IC
22-003(d)	22	90 SWMU	Satellite storage	Aactive	1	ORG,INORG,METALS,SOLV,ACIDS,CAUST	CARBC;IC
22-003(e)	22	90 SWMU	Satellite storage	Active	1	ORG,INORG,METALS,SOLV,ACIDS,CAUST	CARBC;IC
22-003(f)	22	90 SWMU	Satellite storage	Active	1	HE, ORG, INORG, METALS	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
22-003(g)	22	88 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
22-010(a)	22	A SWMU	Septic system	Active	7	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
22-010(b)	22	A SWMU	Septic system	Active	43	RAD, HE, ORG, INORG, METALS, SOLVE	CARBC;IC
22-011	22	A SWMU	Disposal pit	Inactive	89	RAD, ORG, INORG, METALS	CARBC;IC
22-012	22	88 SWMU	Decontamination facility	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
22-013	22	88 SWMU	Aboveground tank	Active	10	ORG, INORG, METALS, ACIDS	CARBC;IC
22-014(a)	22	88 SWMU	Sump	Active	16	HE, ORG, INORG, METALS	CARBC;IC
22-014(b)	22	A SWMU	Sump	Active	2	HE,ORG,INORG,METALS,SOLV,PHOCHEM	CARBC;IC
22-015(a)	22	A SWMU	Drain lines and dry wells	Inactive	52	ORG, INORG, METALS, ACIDS	CARBC;IC
22-015(b)	22	A SWMU	Sump and outfall	Inactive	2	HE, ORG, INORG, METALS, SOLV	CARBC;IC
22-015(c)	22	B SWMU	Outfall	Inactive	1	ORG, INORG, METALS, ACIDS	CARBC;IC
22-015(d)	22	A SWMU	Drain line and outfall	Inactive	2	HE, ORG, INORG, METALS, SOLV	CARBC;IC
22-015(e)	22	88 SWMU	Sump	Inactive	0	HE, ORG, INORG, METALS, SOLV	CARBC;IC
22-016	22	A SWMU	Septic system	Inactive	17	RAD, ORG, INORG, METALS, SOLV	CARBC;IC
40-001(a)	40	A SWMU	Septic system	inactive	1	ORG, INORG, METALS, SOLV	CARBC;IC
40-001(b)	40	A SWMU	Septic system	Active	6	ORG, INORG, METALS, SOLV	CARBC;IC

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PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
40-001(c)	40	A SWMU	Septic system	Active	3	ORG, INORG, METALS, SOLV	CARBC;IC
40-002(a)	40	88 SWMU	Storage area	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
40-002(b)	40	88 SWMU	Storage area	Active	1	HE, ORG, INORG, METALS	CARBC;IC
40-002(c)	40	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
40-003(a)	40	A SWMU	Firing site	Inactive	1613	HE, ORG, INORG, METALS, HERBICIDE	CARBC;IC
40-003(b)	40	88 SWMU	Firing site	Inactive	807	HE, ORG, INORG, METALS, HERBICIDE	CARBC;IC
40-005	40	A SWMU	Sump	Active	5	RAD, HE, ORG, INORG, METALS, BA	CARBC;IC
40-006(a)	40	A SWMU	Firing site	Active	3	RAD, HE, ORG, INORG, METALS	CARBC;IC
40-006(b)	40	A SWMU	Firing site	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
40-006(c)	40	A SWMU	Firing site	Active	1	RAD, HE, ORG, INORG, METALS	CARBC;IC
40-007(a)	40	88 SWMU	Storage area	Inactive	26	HE, ORG, INORG, METALS	CARBC;IC
40-007(b)	40	88 SWMU	Storage area	Inactive	1	HE, ORG, INORG, METALS	CARBC;IC
40-007(c)	40	88 SWMU	Storage area	Inactive	17	HE, ORG, INORG, METALS	CARBC;IC
40-007(d)	40	88 SWMU	Storage area	Inactive	15	HE, ORG, INORG, METALS	CARBC;IC
40-007(e)	40	88 SWMU	Storage area	Inactive	50	HE, ORG, INORG, METALS	CARBC;IC
40-008	40	88 SWMU	Storage area	Decommission	16	HE, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1111

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
40-009	40	A SWMU	Landfill	Inactive	12800	RAD, HE, ORG, INORG, METALS	CARBC;IC
C-40-001	40	AOC	Usage site	Inactive	4444	ORG, INORG, METALS, HERBICIDE	CARBC;IC

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PRS Information for OU # 1114

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-001(a)	3	A SWMU	Satellite storage	Active	6	ORG, INORG, METALS, SOLV, ACIDS	CARBC;IC
3-001(b)	3	A SWMU	Satellite storage	Active	5	ORG, INORG, METALS, SOLV, PHOCHEM	CARBC;IC
3-001(c)	3	A SWMU	<90 day storage	Active	3	RAD, ORG, INORG, METALS, PET	CARBC;IC
3-001(d)	3	88 SWMU	Satellite storage	Active	1	RAD, ORG, INORG, METALS, PET	CARBC;IC
3-001(e)	3	88 SWMU	<90 day storage	Active	3	RAD, ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-001(f)	3	88 SWMU	Satellite storage	Active	2	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(g)	3	88 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(h)	3	88 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(i)	3	88 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, PET	CARBC;IC
3-001(j)	3	88 SWMU	Satellite storage	Active	1	ORG, INORG, METALS	CARBC;IC
3-001(k)	3	A SWMU	Satellite storage	Active	1	RAD, ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-001(l)	3	88 SWMU	<90 day storage	Active	3	ORG, INORG, METALS	CARBC;IC
3-001(m)	3	A SWMU	Satellite storage	Active	1	ORG, INORG, METALS	CARBC;IC
3-001(n)	3	90 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-001(o)	3	90 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV, ACIDS	CARBC;IC
3-001(p)	3	A SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC

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PRS Information for OU # 1114

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-001(q)	3	90 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(r)	3	A SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(s)	3	90 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(t)	3	90 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(u)	3	90 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(v)	3	90 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(w)	3	90 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, PESTICIDES	CARBC;IC
3-001(x)	3	90 SWMU	Satellite storage	Active	1	ORG, INORG, METALS, SOLV	CARBC;IC
3-001(y)	3	90 SWMU	Satellite storage	Active	0	ORG, INORG, METALS, SOLV	CARBC;IC
3-002(a)	3	88 SWMU	Storage area	Inactive	2	ORG, INORG, METALS, ACIDS	CARBC;IC
3-002(b)	3	A SWMU	Storage area	Inactive	1	ORG, INORG, METALS, SOLV, PET	CARBC;IC
3-002(c)	3	A SWMU	Storage area	Inactive	71	ORG, INORG, METALS, PESTICIDES	CARBC;IC
3-002(d)	3	90 SWMU	Storage area	Inactive	1	ORG, INORG, METALS, PET	CARBC;IC
3-003(a)	3	A SWMU	Storage area	Inactive	1	ORG, INORG, METALS	CARBC;IC
3-003(b)	3	A SWMU	Storage area	Inactive	1	ORG, INORG, METALS	CARBC;IC
3-003(c)	3	A SWMU	Storage area	Decommission	2	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1114

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-003(d)	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
3-003(e)	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
3-003(f)	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
3-003(g)	3	90 SWMU	One-time spill	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
3-003(h)	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
3-003(i)	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
3-003(j)	3	90 SWMU	Storage area	Active	2	ORG, INORG, METALS, PCB	CARBC;IC
3-003(k)	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
3-003(l)	3	90 SWMU	Storage area	Inactive	1	ORG, INORG, METALS, PCB	CARBC;IC
3-003(m)	3	90 SWMU	Storage area	Active	3	ORG, INORG, METALS, PCB	CARBC;IC
3-003(n)	3	90 SWMU	Storage area	Inactive	1	ORG, INORG, METALS, PCB	CARBC;IC
3-003(o)	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS, PCB	CARBC;IC
3-003(p)	3	90 SWMU	Storage area	Inactive	1	ORG, INORG, METALS, PCB	CARBC;IC
3-004(a)	3	88 SWMU	Container storage	Active	5	ORG, INORG, METALS	CARBC;IC
3-004(b)	3	88 SWMU	Container storage	Unknown	4	RAD, ORG, INORG, METALS	CARBC;IC
3-004(c)	3	90 SWMU	Storage area	Active	20	RAD, ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1114

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-004(d)	3	90 SWMU	Storage area	Active	10	ORG, INORG, METALS, ACIDS	CARBC;IC
3-004(e)	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
3-004(f)	3	90 SWMU	Storage area	Active	1	ORG, INORG, METALS	CARBC;IC
3-006	3	88 SWMU	Burn site	Decommission	0		CARBC;IC
3-007	3	88 SWMU	Firing site	Inactive	12	HE, ORG, INORG, METALS	CARBC;IC
3-008(a)	3	88 SWMU	Firing site	Decommission	627	ORG, INORG, METALS	CARBC;IC
3-008(b)	3	88 SWMU	Firing site	Decommission	46	RAD, ORG, INORG, METALS	CARBC;IC
3-009(a)	3	A SWMU	Surface disposal	Inactive	667	ORG, INORG, METALS, ASBESTOS	CARBC;IC
3-009(b)	3	A SWMU	Surface disposal	inactive	1613	ORG, INORG, METALS	CARBC;IC
3-009(c)	3	A SWMU	Surface disposal	Inactive	1481	ORG, INORG, METALS	CARBC;IC
3-009(d)	3	A SWMU	Surface disposal	inactive	17778	ORG, INORG, METALS	CARBC;IC
3-009(e)	3	A SWMU	Surface disposal	Inactive	185	ORG, INORG, METALS	CARBC;IC
3-009(f)	3	A SWMU	Surface disposal	Inactive	2222	ORG, INORG, METALS	CARBC;IC
3-009(g)	3	A SWMU	Surface disposal	Inactive	4444	ORG, INORG, METALS	CARBC;IC
3-009(h)	3	A SWMU	Surface disposal	Inactive	8324	ORG, INORG, METALS	CARBS;IC
3-009(i)	3	90 SWMU	Surface disposal	Inactive	0	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1114

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-009(j)	3	90 SWMU	Surface disposal	Inactive	0	ORG, INORG, METALS	CARBC;IC
3-010(a)	3	B SWMU	Systematic release site	Inactive	2	HE, ORG, INORG, METALS	CARBC;IC
3-010(b)	3	B SWMU	Machinery	Inactive	1	HE, ORG, INORG, METALS, PET	CARBC;IC
3-010(c)	3	B SWMU	Machinery	Inactive	1	ORG, INORG, METALS, PET	CARBC;IC
3-010(d)	3	B SWMU	Machinery	Inactive	1	ORG, INORG, METALS, PET	CARBC;IC
3-011	3	88 SWMU	Usage site	Inactive	2	ORG, INORG, METALS	CARBC;IC
3-012(a)	3	B SMWU	One-time spill	Inactive	23	ORG, INORG, METALS, SOLV	CARBC;IC
3-012(b)	3	B SWMU	Occasional release site and outfall	Inactive	160000	ORG, INORG, METALS	CARBC;IC
3-013(a)	3	B SWMU	Storm drainage	Active	33	ORG, INORG, METALS, SOLV, ACIDS	CARBC;IC
3-013(b)	3	B SWMU	Drain line	Active	53	ORG, INORG, METALS, SOLV	CARBC;IC
3-013(c)	3	B SWMU	Occasional spill	Active	17	ORG, INORG, METALS, ASPHALT	CARBC;IC
3-013(d)	3	B SWMU	Machinery	Active	1	ORG, INORG, METALS, PET	CARBC;IC
3-013(e)	3	B SWMU	One-time spill	Active	93	ORG, INORG, METALS	CARBC;IC
3-013(f)	3	B SWMU	Non-intentional release area	Inactive	1	ORG, INORG, METALS, PET	CARBC;IC
3-013(g)	3	B SWMU	Collection site	Active	1	ORG, INORG, METALS, PET	CARBC;IC
3-013(h)	3	B SWMU	Storage area	Active	0	ORG, INORG, METALS, PET	CARBC;IC

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PRS Information for OU # 1114

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-014(a)	3	A SWMU	Waste water treatment facility	Active	46	ORG, INORG, METALS	CARBC;IC
3-014(a2)	3	90 SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS	CARBC;IC
3-014(b)	3	A SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS	CARBC;IC
3-014(b2)	3	90 SWMU	Outfall	Active	0	ORG, INORG, METALS	CARBC;IC
3-014(c)	3	A SWMU	Waste water treatment facility	Active	20	ORG, INORG, METALS	CARBC;IC
3-014(c2)	3	90 SWMU	Outfall	Inactive	0	ORG, INORG, METALS	CARBC;IC
3-014(d)	3	A SWMU	Waste water treatment facility	Active	36	ORG, INORG, METALS	CARBC;IC
3-014(e)	3	A SWMU	Waste water treatment facility	Active	20	ORG, INORG, METALS	CARBC;IC
3-014(f)	3	A SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS	CARBC;IC
3-014(g)	3	A SWMU	Waste water treatment facility	active	111	ORG, INORG, METALS	CARBC;IC
3-014(h)	3	A SWMU	Waste water treatment facility	Active	36	ORG, INORG, METALS	CARBC;IC
3-014(i)	3	A SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS	CARBC;IC
3-014(j)	3	A SWMU	Waste water treatment facility	Active	93	ORG, INORG, METALS	CARBC;IC
3-014(k)	3	A SWMU	Waste water treatment facility	Active	6	ORG, INORG, METALS	CARBC;IC
3-014(l)	3	A SWMU	Waste water treatment facility	Active	15	ORG, INORG, METALS	CARBC;IC
3-014(m)	3	A SWMU	Waste water treatment facility	Active	15	ORG, INORG, METALS	CARBC;IC

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PRS Information for OU # 1114

PRS ID	TA	Class	Site Type	Status	Waste Volume (Yd^3)	Potential Contaminants	Potential Remediation
3-014(n)	3	A SWMU	Waste water treatment facility	Active	15	ORG, INORG, METALS	CARBC;IC
3-014(o)	3	A SWMU	Waste water treatment facility	Active	400	ORG, INORG, METALS	CARBC;IC
3-014(p)	3	A SWMU	Waste water treatment facility	Active	19	ORG, INORG, METALS	CARBC;IC
3-014(q)	3	A SWMU	Waste water treatment facility	Active	92	ORG, INORG, METALS	CARBC;IC
3-014(r)	3	A SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS	CARBC;IC
3-014(s)	3	A SWMU	Waste water treatment facility	Active	8	ORG, INORG, METALS	CARBC;IC
3-014(t)	3	A SWMU	Waste water treatment facility	Active	8	ORG, INORG, METALS	CARBC;IC
3-014(u)	3	A SWMU	Waste water treatment facility	Active	17	ORG, INORG, METALS, PHOCHEM	CARBC;IC
3-014(v)	3	90 SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS, PHOCHEM	CARBC;IC
3-014(w)	3	90 SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS	CARBC;IC
3-014(x)	3	90 SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS	CARBC;IC
3-014(y)	3	90 SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS	CARBC;IC
3-014(z)	3	90 SWMU	Waste water treatment facility	Active	1	ORG, INORG, METALS	CARBC;IC
3-015	3	B SWMU	Outfall	Inactive	1852	RAD, ORG, INORG, METALS	CARBC;IC
3-016(a)	3	88 SWMU	Septic system	Active	5	ORG, INORG, METALS	CARBC;IC
3-016(b)	3	88 SWMU	Septic system	Active	5	ORG, INORG, METALS	CARBC;IC

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■ APPENDIX G

Observational Approach to Environmental Restoration

1.0 INTRODUCTION

1.1 Purpose and Scope

This appendix summarizes the observational approach to geotechnical engineering and describes how this approach can be applied to the Environmental Restoration (ER) Program at Los Alamos National Laboratory (the Laboratory). The observational approach is a major component of the Laboratory's streamlined approach for environmental restoration. The example case study is intended to illustrate the philosophy, general approach, and thought processes involved in the observational approach so that it can be adapted for use in remediating operable units (OUs) at the Laboratory as required by the Resource Conservation and Recovery Act (RCRA).

1.2 Overview of the Observational Approach

A flexible observational approach to remediating waste sites has been endorsed in concept by the US National Research Council (1989, 0387), the Department of Energy (DOE) (1990, 0079), and the Environmental Protection Agency (EPA) (1989, 0300). The observational approach described here is based on the observational method, which is a technique used by geotechnical engineers to manage uncertain surface designs. The observational method was first formalized by Karl Terzaghi (Peck 1969, 0369; Dunnicliff and Deere 1984, 0279). More recently, others (Wallace 1987, 0391; 1988, 0392; Sturges et al. 1988, 0380; Mark et al. 1989, 0350; Myers and Gianti 1989, 0355; Duplanic and Buckle 1989, 0280) have discussed the application of the observational method to remediation of waste sites.

The philosophy of the observational approach as it applies to waste remediation is that remedial action can and should be initiated without a "full" (that is, overly detailed) description of the nature and extent of contamination. Its use is based on the following observations, drawn from geotechnical engineering experience, from EPA, and from other experience with early environmental restoration efforts:

- Inherent uncertainties in waste remediation cannot be completely eliminated.
- Protracted investigations and characterization studies do little to reduce inherent uncertainties at waste sites.
- Confidence in any remediation effort is achieved only through field verification and monitoring the waste site during and following remediation.

The observational approach, which provides a logical and effective approach to planning, designing, and implementing remedial actions, includes the following components:

- Conducting sufficient characterization (investigation, modeling, etc.) to provide a general understanding of probable conditions and reasonable deviations. The appropriate level of site characterization is indicated by the historic uses of the site and the technologies proposed for remediation.

- Evaluating all remedial alternatives based on probable site conditions.
- Continuing site characterization until remaining reasonable deviations from probable conditions can be addressed by contingency plans incorporated in the remedial alternative that is optimal under the probable conditions.
- Selecting a remedial alternative based on the probable conditions and planning and designing contingency plans to address reasonable deviations.
- Selecting physical and chemical parameters to be monitored at the waste site to confirm probable conditions or to detect anticipated deviations.
- Calculating or estimating the value of these physical and chemical parameters (e.g., hydraulic conductivity and contaminant concentrations) for the waste site expected during remediation both for the probable conditions and for all reasonable deviations.
- Constructing and implementing the remedial design based on probable conditions.
- Monitoring the selected physical and chemical parameters to identify deviations.
- Modifying the remedial action according to prepared contingency plans in response to the occurrence of deviations.

1.3 Overview of the General Case Example

The hypothetical example described in this appendix illustrates how the observational approach might apply to a potential release site (PRS) at the Laboratory. The relationship between the RCRA corrective action program and the observational approach is illustrated in the generalized decision diagram (Figure G-1), which defines the steps in the corrective action process when the observational approach is used. The steps of the RCRA process [i.e., RCRA facility assessment (RFA), RCRA facility investigation (RFI), corrective measures study (CMS), and corrective measures implementation (CMI)] are shown with the approximate corresponding portions of the decision diagram. Although these steps appear as discrete phases in many discussions of the RCRA process, they are actually closely interrelated and should not be treated as merely sequential components of the process. The interrelationship is shown in the decision diagram. For example, obtaining site characterization data is typically thought of as part of the RFA/RFI; however, additional site characterization data could be required in any part of the corrective action program. Indeed, in using the observational approach, action is initiated as soon as sufficient data are available. Additional data are expected to be collected at later stages of the corrective action process.

In this appendix, a hypothetical case that includes some of the measures the Laboratory expects to use for remediation is analyzed according to the process shown in the Figure G-1. The example begins with a description of a conceptual

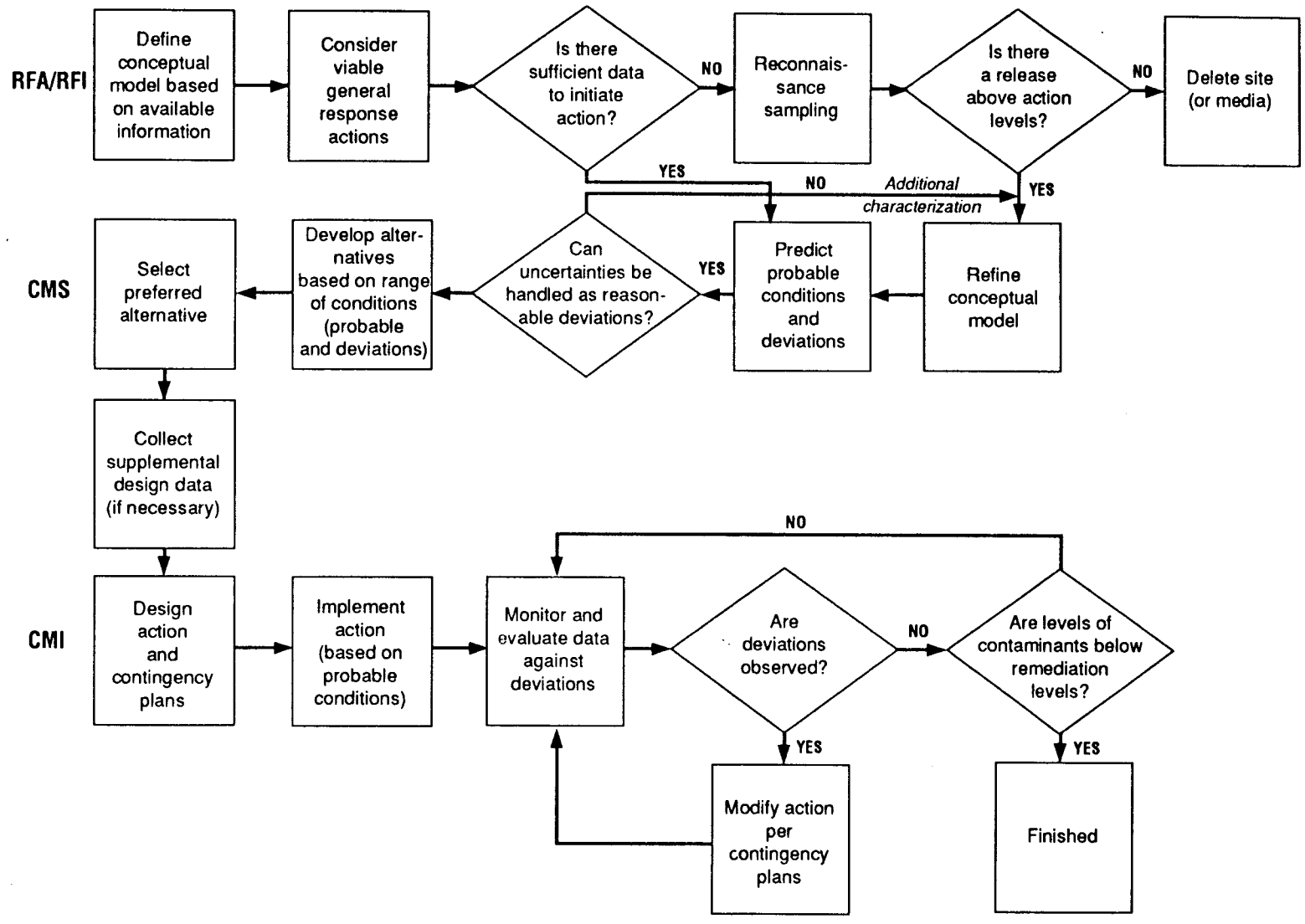

Figure G-1. Generalized decision diagram of the observational approach.

exposure model based on existing information and progresses through the corrective action process as described by the decision diagram. The case example is organized as sections that correspond approximately to the steps of the RCRA process.

The visible benefits of using the observational approach to site remediation at the Laboratory vary considerably, depending on site-specific conditions, and, in some cases, the benefits are not visible at all. For instance, the results of using the observational approach to clean up firing sites may not differ visibly from the results obtained without using the observational approach. Therefore, it is important to recognize the intangible benefits of the thought process inherent in the observational approach (i.e., recognizing that uncertainty exists, obtaining sufficient data, identifying probable conditions and reasonable deviations, and preparing contingency plans). Using this approach in every case is important because, without it, it is not possible to know whether existing data are sufficient to identify probable conditions and reasonable deviations that might occur and how to respond to them.

2.0 GENERAL CASE EXAMPLE

This example is intended to illustrate how the observational approach could be applied to planning and implementing remediation of material disposal areas (MDAs) and landfills at the Laboratory.

2.1 RCRA Facility Assessment/RCRA Facility Investigation

2.1.1 Facility Description

MDAs at the Laboratory typically contain a wide range of hazardous wastes and low-level radioactive wastes (LLW) (i.e., mixed wastes). Both solid and liquid wastes have been disposed in pits, trenches, adsorption beds, and shafts at MDAs. In general, the Laboratory sited the MDAs on mesa tops adjacent to technical areas.

The hypothetical MDA examined in this case example was identified as a PRS during the RFA. The MDA covers about 5 acres and is located on a mesa top (Figure G-2). A thin layer of soil on the mesa top covers low-permeability, fractured, welded tuff. Groundwater is approximately 1,000 ft beneath the mesa top. During the

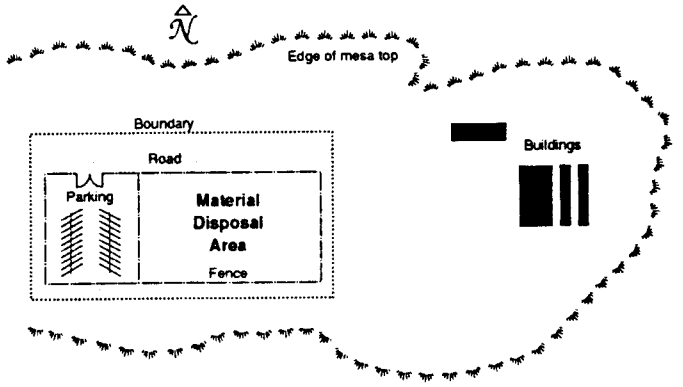

Figure G-2. Hypothetical case example.

summer, short, intense thunderstorms commonly cause surface run-off that may carry topsoil into the adjacent canyon. In addition, persistent erosion of surface soils is occurring at the southern edge of the mesa top. The eroded soil from the southern edge and possibly soil suspended in run-off could be transported into the adjacent canyon. Environmental monitoring records indicate that the canyon has ephemeral streamflow during thunderstorms.

Laboratory records show that radioactive solid waste and hazardous wastes consisting of liquids and corrosive gases were disposed at this MDA in the late 1940s. The MDA consists of a pit and trenches. It is not clear whether the pit is actually a series of separate pits or is one large pit that was expanded as necessary. The pit covers most of the MDA's surface area. The western portion of the MDA (which included some of the inactive pit area) was leased to the county in the 1960s and was subsequently paved with asphalt for use as parking space. Wastes buried in the pits are thought to consist primarily of solid LLW (e.g., contaminated clothing, pumps) generated during ordinary Laboratory operations. Solid waste known to be located at the MDA includes one truck contaminated with fission products and various isotopes of plutonium, polonium, uranium, americium, curium, and actinium. Trenches of an unknown number and size are thought to be located along the eastern edge of the MDA. Bottles disposed in the trenches are thought to contain various mixtures of unknown volatile organic chemicals and corrosive gases. There is no indication that contaminant migration has occurred at the MDA, nor is there any known surface or groundwater contamination.

The RFA determined that portions of the MDA contained concentrations of volatile organics that exceeded the action levels defined by EPA's interim RFI guidance (EPA 1989, 0088). Because of a lack of data, it was not possible to assess the levels of other possible mixed-waste contaminants. However, in anticipation that the RFI would lead EPA to require a CMS for the volatile organics, the Laboratory requested and received the designation of the entire MDA as a PRS.

2.1.2 Development of the Conceptual Model

Based on existing knowledge, a conceptual exposure model of the MDA was developed to identify possible contaminant sources, release mechanisms, contaminated media, migration pathways, and receptors. During this process, sources, pathways, and contaminated media determined to be unlikely candidates were screened out. The resulting conceptual model (Figure G-3) identifies the probable conditions at the site based on available data, information, and technical judgment at that time.

The conceptual exposure model of the MDA identified three possible contaminant sources: the pit(s) used for solid waste, the trenches used for bottled liquids and corrosive gases, and the paved portion of the MDA. Probable release mechanisms from these sources include unsaturated flow and transport, volatilization of organics, and erosion of surface soils. These release mechanisms may result in contamination of biota, vadose zone soils, surface soils, and air. Migration of the contaminants can occur through the vadose zone soils, surface soils, overland run-off, and air. The contamination could reach human and environmental receptors through direct dermal contact with soil, biota, and air; ingestion of soil, biota, and air; and inhalation of air. It is assumed that contaminant migration to the groundwater is not a concern because depth to the water table is more than 1,000 ft.

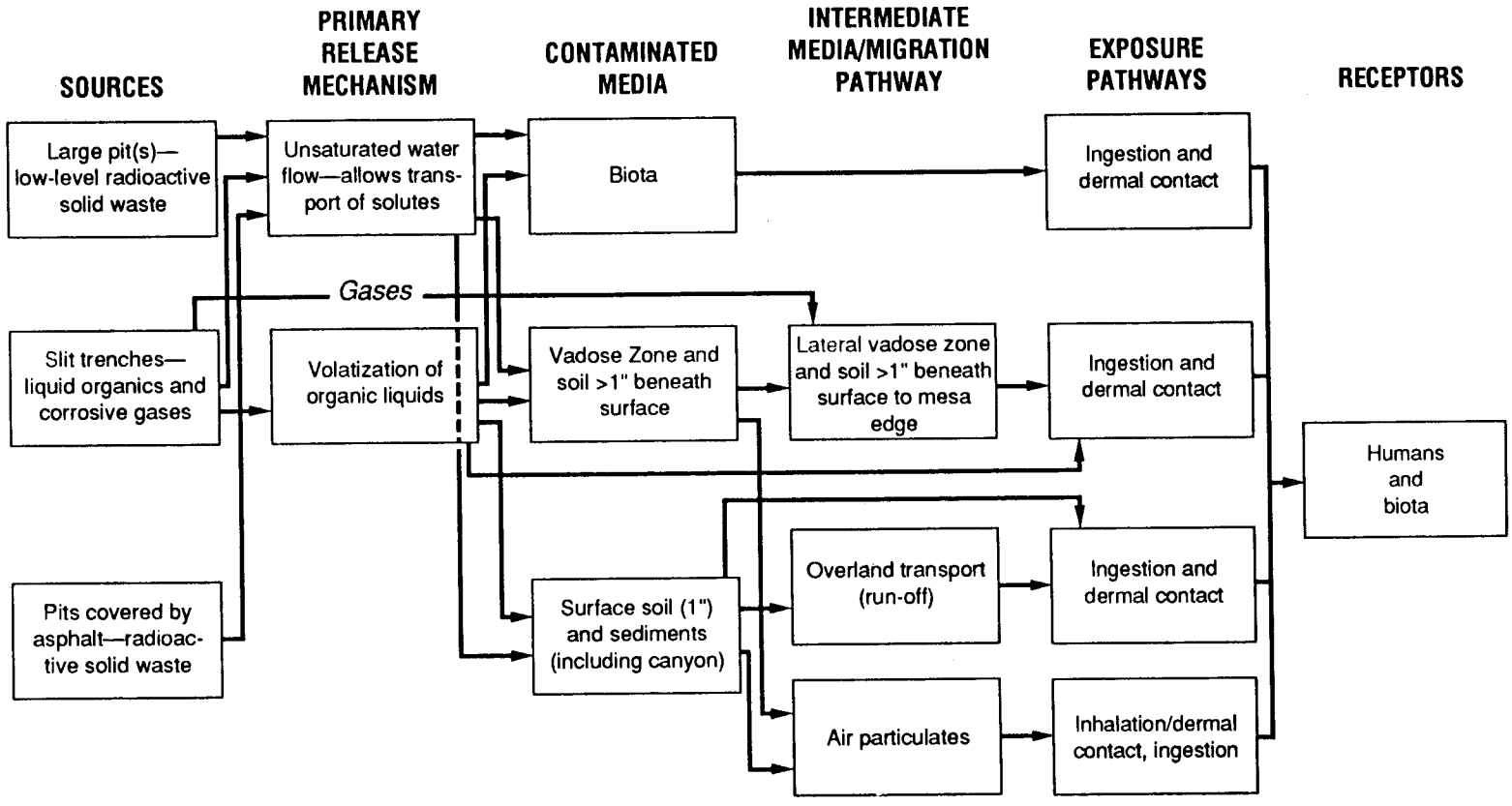

Figure G-3. Conceptual model of case example.

The conceptual model identified the following probable conditions:

- Surface soils and the upper part of the vadose zone have been contaminated by volatile organics to concentrations above action levels.
- During storms, run-off causes contaminant concentrations in the soils at the southern edge of the mesa to exceed action levels.
- Contaminant concentration levels in the air are below action levels.
- Because the ambient vadose zone moisture is extremely low, there is little opportunity for solid waste to migrate. Evidence obtained from other MDAs supports this assumption.
- Contaminants do not migrate to the groundwater because the distance to the water table is so great.
- The source term, which probably includes organic liquids, volatile organics, corrosive gases, and LLW and which covers a large area, is very complex and dangerous.

Major uncertainties in the conceptual exposure model are

- the extent of lateral and vertical movement of volatile organics,
- the extent of contamination of the mesa's southern edge and the canyon,
- the nature of the chemicals, and
- the volume of liquid in the sources.

2.2 RCRA Facility Investigation/Corrective Measures Study

2.2.1 Screening Viable Responses

Even though there are uncertainties in the conceptual model that must be addressed, preliminary screening of responses based on existing data is possible and appropriate. The following responses are technically feasible and potentially appropriate for this MDA:

- institutional control (fencing, deed control),
- removal (excavation and disposal at an approved landfill),
- containment (capping, slurry walls), and
- in-situ treatment (vapor extraction, in-situ vitrification, stabilization).

Removal and certain in-situ treatments (such as in-situ vitrification) of volatile organics require extensive knowledge, and therefore sampling, of the source term. Because of the physical hazards associated with sampling the source term, these options were eliminated. For this MDA, the preferred response will probably consist of a combination of the remaining responses (i.e., institutional control in conjunction with containment and appropriate in-situ treatment).

2.2.2 Sampling and Analysis Plans

To identify the appropriate combination of corrective actions, it is necessary to refine the conceptual model. Uncertainties in the conceptual model include the location, size, and number of pits and trenches and the types of contaminants. Further evaluation of the general responses cannot be conducted until these uncertainties have been reduced. The goal is to reduce uncertainties to a level that permits identification of probable conditions, prediction of reasonable deviations, and preparation of contingency plans, which requires the following data:

- Identification of the probable location and size of the sources (i.e., pit and trenches). Characterization of the source term is not necessary for the responses under consideration. However, knowledge of the extent of the source is required to evaluate corrective actions. Specific factors include the distance from the sources to the boundaries of the MDA and the mesa edge.

- Better identification of the type and extent of contaminant migration. The specific parameters include lateral and vertical migration of volatile and solid contaminants.

The sampling plan to gather these data includes

- using surface geophysical techniques to identify the location of pits and trenches;

- conducting surveys of surface contamination;

- drilling slant boreholes under the pits and trenches to confirm the assumed vadose zone conditions (i.e., that vertical migration of contaminants is negligible); and

- using soil gas surveys to identify the extent of volatile contaminant migration. Because volatiles are much more mobile than solutes, the extent of volatile contaminant migration will be used as an indication of the maximum extent of contaminant migration.

2.2.3 Results of Reconnaissance Sampling

The data gathered by the RFI Phase I reconnaissance indicated the following:

- The MDA consists of one large pit covering approximately 2.5 acres in the fenced portion and under the paved portion of the

MDA and of two trenches, 40 ft long and 2–3 ft wide, approximately 200 ft from the southern edge of the mesa.

- No surface contamination is present.
- Soil gas surveys indicate limited migration of volatiles. The samples showed discontinuous and isolated migration a maximum of 5 ft laterally from the outside boundary of the trenches. Between the southern edge of the mesa and the trenches, migration also appears to be limited to 5 ft.
- Slant borehole samples did not indicate any downward vertical movement of contaminants.

2.2.4 Revision of the Conceptual Model

In accordance with the newly acquired data, the probable conditions were revised to reflect

- no contamination of the surface soils or the southern edge of the mesa,
- no vertical migration to groundwater,
- limited lateral and vertical migration of volatiles, and
- negligible lateral and vertical migration of solutes.

Uncertainties still exist as to the amount of organic and mixed liquids and corrosive gases remaining in the trenches. Two possibilities exist: (1) either the liquids and gases are still contained in their original containers in the trenches and have not yet migrated or (2) the organic liquids have volatilized and have been released with the corrosive gases.

Characterization of the source term could establish the existence of organic liquids and corrosive gases in the trenches, or their presence could be a deviation. However, because source characterization efforts involve physical risk, an attempt will be made to evaluate corrective actions in which the presence of organic liquids and corrosive gases is addressed as a reasonable deviation.

2.3 Corrective Measures Study and Corrective Measures Implementation

2.3.1 Corrective Action Evaluation and Contingency Plan Preparation

Following the criteria specified in proposed Subpart S [40 CFR Part 264.525 (a, b)] (EPA 1990, 0432) possible corrective actions were evaluated to determine whether they allowed the presence of organic liquids and corrosive gases to be handled as a reasonable deviation. A combination of corrective actions was assumed to be most appropriate for the MDA. An evaluation of the data gathered during reconnaissance sampling supported combining corrective actions.

The following information was used to evaluate the corrective actions:

- the extent of the MDA (pit and trenches),
- the danger involved in characterizing the source term further, and
- the ability of the corrective actions to address the presence of liquids and gases as a reasonable deviation.

Based on these criteria, a combination of institutional control and containment was selected as the preferred corrective action. The DOE will reacquire the paved portion of the MDA, and a fence will be constructed around the entire MDA. A modified cap has been identified as an appropriate corrective action to contain the source and to address the reasonable deviation of the presence of organic liquids and corrosive gases in the trench. The cap will be designed to inhibit infiltration of water and erosion of the soil covering the MDA and to divert surface run-off around the MDA.

To determine what level of detail was required for the contingency plans, the investigators evaluated cost, technical feasibility, and impact of the reasonable deviation. The contingency plan provides for a series of soil gas monitors to be installed under the cap. To respond to the deviation, the plan provides for a network of pipes to capture the volatilized organics and corrosive gases as they move out of the soil surface. It was determined that the pipe network was more feasible technically than attempting to extract soil gas through the installed cap. If migration of contaminants is detected, an air-stripping treatment train (air stripper, activated carbon filter, etc.) will be established to treat the off-gas removed via the pipe network.

The level of detail required for a contingency plan varies. The soil gas monitors and pipe network will be designed and installed with the cap. The treatment train will be designed but not built. The monitoring system will provide for advance notice of migration to allow the treatment train to be constructed.

2.3.2 Corrective Measures Implementation and Monitoring

The corrective actions have been implemented as designed. Monitoring the soil gas between the cap and the trenches has been initiated and is continuing. Monitoring for a deviation will continue for the period specified in the closure permit.

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■ APPENDIX H

Statistical Sampling and Data Analysis for Environmental Restoration

1.0 INTRODUCTION

The characterization and remediation of hazardous waste sites must be carried out with much less than perfect knowledge of true site conditions. Statistics provides some tools for dealing with such uncertainties; however, statistical tools by themselves are not enough to deal with the problems that arise in characterizing hazardous waste sites. Chapter 4 and Appendices G and I of this Installation Work Plan (IWP) discuss other aspects of managing uncertainty during the process required by the Resource Conservation and Recovery Act (RCRA). In particular, statistical specification of a sampling and analysis plan cannot begin until an overall decision flow has been outlined and the questions to be answered using the data have been formulated. Tools ranging from formal multiattribute decision analysis (Appendix I) to the general guidelines of the observational approach (Appendix G) are available to help investigators arrive at useful formulations of decisions and questions and to compare the costs and benefits of acquiring additional information. The discussions in Appendices G and I provide the context within which the statistical methods discussed in this appendix are applied, and familiarity with them is assumed.

Section 2 of this appendix briefly reviews the various models and data collection activities that may occur during the RCRA process. Section 3 considers the relationship between the data quality objectives (DQO) process and the design of sampling and analysis plans. Section 4 describes statistical sampling and data analysis strategies for screening assessments and other preliminary investigations, and Section 5 contains additional information on statistical sampling methods. Section 6 considers sampling and analysis options that are more appropriate for follow-up investigations, which may occasionally be used in Phase I of the RCRA facility investigation (RFI) but which are generally postponed until later phases.

2.0 MODELS AND DATA IN THE RCRA PROCESS

If "model" is defined to mean a decision maker's understanding of the site under investigation, then his/her decision is ultimately based on a model. The types of models used in practice range from implicit models—e.g., sets of assumptions, often based on expert professional judgment but sometimes poorly examined, about the environment and its interactions with the site under study—through nonquantitative conceptual models to fully quantitative, numerical, or probabilistic models.

The central model proposed in this IWP to organize information during the RCRA process is the conceptual exposure model (Appendix G). It is recommended that at a minimum all assumptions be made explicit; implicit models are not sufficient for the decisions that are required under RCRA. Depending on the complexity of the site, refining the conceptual exposure model during the RCRA process may entail constructing quantitative auxiliary models such as

- decision models (Appendix I) to evaluate decision alternatives and the impact of remaining uncertainties,
- statistical models to describe the relationship between the data and the environment,

- environmental transport models to predict potential exposure at points removed from the source of contamination in space and/or time,
- epidemiological dose/risk models for assessing the consequences of exposure under a postulated scenario, and
- engineering calculations to predict the effectiveness of proposed corrective measures as a function of detailed design alternatives.

The goal of site characterization is to provide the environmental data needed for these models at the level of detail needed to make the required decisions. There are several points during the RCRA process at which environmental (and possibly other) data will be collected. Data collection is frequently (but not always) required during the RFI, supplemental data may be necessary to complete detailed remedial design during the corrective measures study (CMS), and some form of monitoring or confirmatory sampling will almost always accompany corrective measures implementation (CMI).

Within the RFI, RCRA guidance documents [such as the Environmental Protection Agency's (EPA's) "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA," (EPA 1988, 0087)] recommend a phased approach to ensure that the site is investigated in a manner that is both cost-effective and that complies with the Hazardous and Solid Waste Amendments (HSWA) Module of the Laboratory's permit to operate under RCRA (EPA 1990, 0306). Each phase of the RFI concludes with a decision about the next step to be taken in the RCRA process, based on evaluation of the data available at that point and the correspondingly refined site conceptual model (Figure 4-1). In this IWP, "RFI Phase I" refers to the work described in detail in the initial RFI work plan. If a second phase is necessary, the scope of RFI Phase II, by definition, depends on the outcome of RFI Phase I and therefore cannot be described in detail in the initial RFI work plan. However, its probable objectives can be outlined, and potential alternatives to Phase II (such as no further action or proceeding immediately to the CMS) should be clearly stated, along with the criteria to be used in selecting among them.

Frequently, but not always, RFI Phase I consists of a screening assessment because, for many sites, the existing data and other information are not sufficient to determine which constituents, if any, are contaminants of concern at a potential release site (PRS). Section 4.1.3 of the IWP outlines the major categories for preliminary investigations to support a screening assessment:

- reconnaissance sampling, to establish whether contamination is present above screening action levels (SALs),
- limited investigations to confirm the appropriateness of voluntary corrective action, and
- sampling or monitoring sites that are candidates for deferred action.

These categories are discussed further in Section 4 of this appendix.

For those few sites for which a substantial data base exists, a conceptual exposure model that is already partially quantified can be constructed before initiating RFI work. In this case, RFI Phase I sampling may be more specifically designed to support baseline risk assessment or to design a corrective measure. Its objectives, and those of RFI Phase II and subsequent site characterization, must therefore be tailored both to the specific site and to the remaining uncertainties that prevent the investigator from completing the RFI. The investigator determines the appropriate level of detail, using the principles described in Appendix G and exploiting as appropriate the opportunities for further data collection that will arise during CMI. General sampling and data analysis strategies for such follow-up investigations are discussed in Section 6 of this appendix.

3.0 SPECIFICATIONS FOR SAMPLING AND ANALYSIS PLANS

As presented by EPA (1991, 0813), the DQO process is part common sense, part good management practice, and part statistics. It is the purpose of this section to describe the last of these aspects, relating the products of the process to the essential requirements for specifying a statistical sampling plan. Nevertheless, even those steps of the process that require the most statistical input (Steps 5, 6, and 7) raise many nonstatistical issues as well. Thus, all steps of the process require participation by a DQO planning team consisting of program managers and a variety of technical experts, as well as a statistician.

The seven steps of the process described by EPA (1991, 0813) have been outlined in Section 4.1.2. The product of Step 1 is a description of the problem, together with resource, time, and other practical limits on data collection. The conceptual exposure model provides a useful framework for organizing the archival information so that the gaps in existing knowledge that significantly affect the investigator's ability to perform the required assessments are readily identified. A decision model (Appendix I) may be superimposed on this conceptual exposure model to assist this identification process.

It is neither feasible nor necessary to address all uncertainties at once. Step 2 of the DQO process therefore focuses on the immediate decisions that need to be made—those that define the current phase of the project. Its product is a statement of choices among alternative courses of action, framed as narrowly and specifically as possible. This decision must be stated in such a way that it is clear what the role of data will be in deciding what action, if any, to take. This focus differentiates data collection for environmental decision making, as required under RCRA, from data collection for research purposes.

Occasionally these first two steps may lead to a "decision" that can be made immediately—that is, there may be only one course of action that appears to be reasonable on the basis of the archival information. Examples are the "no further action" and "deferred investigation" decisions mentioned in Section 4.1.1. In these cases, it is not necessary to proceed further with the DQO process.

Otherwise, Step 3 of the DQO process begins to turn the decision statement into a set of specifications for a sampling and analysis plan. Its product is a list of "decision inputs," that is, information required to make the decision. These inputs are the environmental variables or parameters to be measured (called *outcome variables* in the statistical survey sampling literature). If none of the required decision inputs are environmental parameters for which new data must be collected, then again it is

possible to exit from the DQO process after the required existing information has been assembled.

When new, site-specific environmental data are required, a further series of questions must be addressed in order to complete the specification of a sampling and analysis plan to acquire them. These questions are developed in Steps 4, 5, and 6 of the DQO process. Step 4 is to "define the boundaries of the study," or, in traditional statistical terminology, to specify the *target population(s)*, which includes specifying both the spatial and temporal boundaries of the population to be sampled, as well as the media of interest. Examples of outcome variables and target population are

- radionuclide concentrations in the top 6 in. of soil within a defined area of interest, where radionuclide concentrations are assumed to be more or less stable so that temporal boundaries need not be specified;

- contaminant concentrations in a shallow alluvial aquifer beneath and for 200 ft downgradient from a PRS, to be measured quarterly until the site is decommissioned; and

- particulate density and size distribution in air within 500 m of the site perimeter during March, April, and May.

It is also necessary to specify quite precisely the physical methods that will be used to collect the sample and how measurements on this sample are assumed to be related to the population parameters of interest. Sometimes this relationship is fairly complex, as when filters left on a site for days, weeks, or months are used to sample particulates in air. Even for surface soil, sieving or other methods of preparing samples may result in a sample whose relationship to the target population is not simple.

Step 5 is to "develop a decision rule," and its product is a statement that defines how environmental data will be summarized (i.e., a statement that specifies the *statistic* to be calculated) and used to make the decision (the *criterion* for a statistical *hypothesis test*). The decision rule can vary from the simple to the very complex. For example, the data might be summarized by the sample maximum, which is then compared with an SAL. At the other extreme, concentration data might be interpolated in a full three-dimensional grid, which, in turn, is used by a computerized transport model to predict how long it will take for the contaminant to move offsite, and this predicted travel time is compared with regulatory requirements or contaminant decay times.

Finally, Step 6 is to "specify limits on uncertainty." Because environmental data are both incomplete (that is, statistical inference must be based on the small fraction of the target population that is observed) and subject to error (both measurement error and biases introduced by sample collection and preparation), there is some probability that the decision rule developed in Step 5 will produce the wrong answer, which, in turn, leads to an incorrect decision in Step 2. The investigator must consider the impacts of various types of errors in the Step 2 decision:

- What are the possible types of errors: cleaning up a site that has no serious impacts? failing to detect a significant release?

- What are the penalties associated with each type of error: monetary costs? legal liability? negative public perception? unnecessary restrictions on Laboratory operations?

- How averse are investigators to making each type of error? Specifically, for what range of the true parameter values is either decision acceptable? At what extremes do errors become highly unacceptable?

Turning these decision requirements into des*ign criteria* for the sampling and analysis plan is generally a difficult task, involving some assumptions about the likely sampling variability and probable site conditions. Nevertheless, some attempt should be made to address these questions because their answers provide some basis for determining sample sizes and analytical requirements that are both adequate and reasonable.

Step 6 completes the specifications for a sampling and analysis plan: what is to be measured? for what population? how will the data be used? and what is the margin for error? These specifications can be met in a number of ways; thus, the seventh and final step of the DQO process is to design a sampling and analysis plan to meet them efficiently. Here, a number of further options, such as the following, can be considered:

- How can relatively inexpensive field surveys and field screening results be used to direct the selection of samples for laboratory analysis and possibly to supplement those analytical results?

- Should the target population be stratified to reduce the variability of the computed statistics?

- Can samples be composited to decrease analytical costs?

- What level of analytical precision is required, and what analytical methods guarantee such levels?

4.0 SAMPLE DESIGNS FOR PRELIMINARY INVESTIGATIONS

Most RFI Phase I work at Los Alamos consists of investigations to support a screening assessment: reconnaissance investigations, limited investigations before implementing voluntary corrective actions or to justify deferred action, or monitoring sites at which action will be deferred. The ER Program may not have responsibility for monitoring because other groups in the Laboratory perform environmental surveillance. ER Program investigators need to verify, however, that appropriate monitoring data are being collected if they propose to defer investigation.

Both reconnaissance sampling (Section 4.1) and limited investigations for voluntary corrective action or deferred action (Section 4.2) are designed to bound the problem. Reconnaissance sampling seeks to bound the level of contamination at a PRS, and voluntary corrective action and deferred-action investigations seek to bound its extent. Each is designed to detect contamination, if present, above SALs in its domain of interest, but the domains are different.

There are also cases where it is desirable to collect data to support a preliminary baseline risk assessment during Phase I of the RFI (Section 4.3), which occur when existing data are sufficient to identify the contaminants of concern. In other cases, the investigator may anticipate performing baseline risk assessment using the same data that were collected for screening assessment, provided that screening assessment does identify one or more contaminants of concern.

4.1 Reconnaissance Sampling

Reconnaissance sampling addresses the question of whether contamination is present above a level of potential concern (defined by SALs) at a PRS. The solid waste management units (SWMU) report (LANL 1990, 0145) contains many PRSs for which not even this much information is available. The problem is therefore defined as detecting contamination, if present at the site, and the sample maximum is an appropriate test statistic. Assuming independent observations and ignoring analytical error, the probability, P, that the largest of N observations exceeds the $100q^{th}$ percentile of the contamination over the whole site is given by

$$P = 1 - q^N .$$

[When significant correlation exists among the observations, a similar expression in terms of an "equivalent sample size" that is less than N is derived by Barnes (1988, 0797)]. Thus, if a fraction, f, of the site is contaminated above SALs, the probability of observing at least one contaminated sample, given N independent measurements, is

$$P = 1 - (1-f)^N . \qquad (4.1)$$

N, the required sample size, is tabulated as a function of f and the desired detection probability, P, in Table H-1.

TABLE H-1

SAMPLE SIZES REQUIRED TO DETECT, WITH PROBABILITY AT LEAST P, CONTAMINATION AFFECTING A FRACTION, f, OF THE SITE

		f									
		0.50	0.45	0.40	0.35	0.30	0.25	0.20	0.15	0.10	0.05
	0.50	1	2	2	2	2	3	4	5	7	14
	0.55	2	2	2	2	3	3	4	5	8	16
	0.60	2	2	2	3	3	4	5	6	9	18
	0.65	2	2	3	3	3	4	5	7	10	21
P	0.70	2	3	3	3	4	5	6	8	12	24
	0.75	2	3	3	4	4	5	7	9	14	28
	0.80	3	3	4	4	5	6	8	10	16	32
	0.85	3	4	4	5	6	7	9	12	19	37
	0.90	4	4	5	6	7	9	11	15	22	45
	0.95	5	6	6	7	9	11	14	19	29	59
	0.99	7	8	10	11	13	17	21	29	44	90

Although the sample sizes required to detect small fractions, f, with high probability, P, are large, more modest requirements lead to reasonable sample sizes. Moreover, if appropriate methods are available for biasing the sample to improve detection—e.g., preferentially sampling stained soil, sediment traps in drainages, or areas with elevated counts in a field radioactivity survey—the actual probability of detection, P, may significantly exceed the probability calculated using Equation 4.1. If small areas of contamination must be detected with high reliability, however, reconnaissance sampling is not appropriate. Such "hot spot" sampling is always expensive and does not qualify as a site-screening strategy (Section 6.2).

Because they are not independent, field duplicates cannot be counted as two samples in making up the total, N. In general, independence is promoted by distributing the samples across the site, avoiding collecting two too close together.

Example

In the past, waste oils at the Laboratory were stored in drums next to the loading dock of a facility before being shipped to a permanent disposal or recycling facility. The area in this example is unpaved and is not precisely demarcated; however, it is not more than 200 ft^2 in size (about 8 ft wide and up to 25 ft long next to the building). The nature of the operations at the facility suggests that the waste oils have been contaminated with low levels of radioactivity (tritium, natural or enriched uranium, and possibly plutonium) and with other heavy metals, including beryllium. However, there is no record of leakage at the site, which was used during the 1950s and 1960s. Neither field surveys nor sampling has ever been carried out at the site.

In view of this lack of quantitative information, the decision to be made was formulated as follows:

Determine whether contamination is present above SALs. If so, perform a baseline risk assessment for the site, which may involve collecting additional information to determine the average contaminant levels. If not, propose no further action.

New environmental data, specifically, soil contaminant levels at the site, are required to make this decision (together with some other information, including SALs for implicated contaminants). The decision domain is the surface soils in the area on which drums may have been stored. The data for each contaminant (radionuclides, metals, and hydrocarbons) are summarized by the observed sample maximum and are compared with the corresponding screening level. To avoid "false negatives," i.e., deciding that contamination is present when it is not, the analytical methods used must be capable of measuring accurately (within 10%, for example) down to SALs. If contamination is above SALs over more than 20% of the domain, the probability of detecting it should exceed 0.9. Judgmental sampling based on visual inspection and a radioactivity survey may be used.

Table H-1 shows that nominally 11 samples are needed to ensure that at least one will fall in the most contaminated fifth of the domain with probability 0.9 or greater. If it can be assumed that contaminants, if present, are associated with oil stains or with above-background field radiation measurements, this probability can be raised or fewer samples can be taken to attain the same level of assurance. However, it is impossible to quantify the improvement in detection probabilities that could result from using these field indicators. A stratified sampling plan (Section 5.2) that assigns some samples to areas with positive field indications and others to areas with none could be used to provide information for quantifying this improvement. ❑

Example

A 30-acre mesa-top area has been used for two decades for general equipment storage and temporary disposal of construction debris. Until very recently, the area has not been monitored in any way to ensure the exclusion of hazardous materials, although there is no information to suggest that any has ever been brought to the site. The area is sufficiently close to current residential areas and existing utilities to be a candidate for residential development in the future; thus, the appropriate exposure unit for a baseline risk assessment is quite small, about 1/8 acre. On the other hand, because there is no evidence that a release of hazardous material has ever occurred, the extensive sampling that would be required to estimate the mean contamination over each exposure unit cannot be justified. The prediction approach ("kriging"), discussed in Section 6.1 of this appendix, is also inappropriate here, given the heterogeneous nature of site uses and the complete lack of archival information.

What is proposed is a preliminary baseline risk assessment for a sample of exposure units, N. Exposure units will be selected independently, either at random or judgmentally biased by visual evidence of use. Using a residential exposure scenario, the investigator estimates the risk at each exposure unit selected based on an estimate of the mean contamination for that exposure unit. Each risk estimate is treated as one "observation" within the 30-acre PRS. [If no volatile organics are implicated, estimation of the mean contamination within one exposure unit could even be based on a single composite sample (Section 5.1)]. The decision on whether the PRS merits further investigation is based on the largest calculated risk among the N exposure units; thus, Table H-1 can be used to determine an appropriate value for N. ❑

4.2 Limited Investigations for Voluntary Corrective Action or Deferred Action

The second type of screening assessment establishes bounds for the extent of contamination around a PRS rather than for the level of contamination. Sampling plans to support assessments of this kind can be much more limited than investigations to establish "probable conditions and reasonable deviations" at the level of detail necessary to support a CMS.

One use of such limited investigations is to evaluate the feasibility of a proposed voluntary corrective action, for example, to determine whether the volume of soil that is contaminated is small enough to be removed for offsite treatment and disposal. The sampling problem is to detect contamination, but only if it is present outside the expected remediation volume. If contamination has spread beyond the boundaries of this volume, it might be desirable to evaluate one or more alternatives to the proposed corrective action. Within these boundaries, however, the appropriate time to characterize the detailed spatial distribution of contamination is during remediation, not during the RFI.

Often PRSs for which voluntary corrective actions are appropriate are subsurface sites with potentially heterogeneous contaminant distributions resulting from small leaks, such as septic tanks, sumps, or underground storage tanks.

The other use of a limited investigation to bound the extent of contamination is to confirm that corrective action may safely be deferred at an active site. Here again, the critical questions deal with the presence of contamination beyond the boundaries

of the active site, and consideration of the details of its distribution within the site is postponed until the site becomes inactive.

Example

This example is a simplified version of a site described in the RFI Work Plan for OU 1079 (LANL 1992, 0783).

Subsurface soil surrounding and beneath a laboratory septic system with a buried outfall became contaminated with ^{90}Sr. The components of the septic system and the surrounding shallow soils were removed, but fairly high levels of strontium were allowed to remain in the deeper alluvium. The site was then released to Los Alamos County, with a deed restriction prohibiting excavation until 2150. The approximate locations and depths of the residual strontium plumes are known; however, there are no data on nonradioactive contaminants.

At this site, voluntary corrective action may well turn out to be the most cost-effective option. The RFI Phase I decision is to

> determine whether the size of the residual plume exceeds a predetermined volume, VMAX. If not, removal is more cost-effective than detailed characterization; if so, a CMS to consider alternatives (which might require additional investigation of the extent of the plume) is the appropriate course of action. A proposal of no further action may also result if the maximum observed contaminant levels are below levels of concern.

New environmental data (both to evaluate the spread, if any, of the strontium plume since the site was last investigated and to look for nonradioactive contaminants, especially organics) are required to test the hypothesis that the extent of the plume is bounded by VMAX. However, specification of VMAX bounds the level of detail required for the Phase I investigation. The decision domain is centered at the approximately known center of the strontium plume and is a little larger than VMAX. Individual measurements on samples (whose selection may be biased by the results of field screening the drill hole cores for radioactivity) are compared with SALs. The decision involves three choices, and therefore several types of errors are possible, such as

- contamination might not be detected even though it is present and
- the plume might be bigger than VMAX in some directions, even though it is not detected except in the central hole.

The sampling plan designed for the RFI Work Plan for OU 1079 (LANL 1992, 0783) consists of four initial drill holes, one of which is located at what is thought to be the center of the plume. The spacing of the remaining three is determined by VMAX. Limited additional drilling may be necessary if the estimate of the plume center turns out to have been inaccurate.

4.3 Preliminary and Baseline Risk Assessment

There are important differences between sampling plans designed for baseline risk assessment and those designed for screening assessment only. The most critical

difference is the need to generate unbiased estimates of mean contamination levels (within the site, within exposure units, or along environmental migration pathways) if the data are to be used in baseline risk assessment. Generating unbiased estimates requires selecting samples that are representative of all of the relevant media and populations, unlike reconnaissance sampling, which may legitimately be biased by expert judgment or field indicators.

The standard estimator (that is, statistic) for a population mean is the sample mean,

$$\bar{x} = \frac{1}{N} \sum_{i=1}^{N} x_i \ , \tag{4.2}$$

where x_i is the measurement of the outcome variable on the ith sample. Again, assuming statistical independence of the observations, this estimator has variance

$$\frac{\sigma^2 + \theta^2}{N} \ , \tag{4.3}$$

where σ^2 is the between-sample variance and θ^2 is the variance of the analytical error. If the observations are correlated, Equation 4.3 does not hold, but if the between-sample correlations can be estimated [based, for example, on an estimated spatial covariance function (Section 5.4)], this expression can be modified.

As Equation 4.3 shows, the precision with which a population mean can be estimated depends not only on the sample size but also on the population variance (about which there is often no information), as well as on analytical error variance, which may or may not be reliably provided by the laboratory or by the instrument manufacturer. Therefore, determining an appropriate sample size involves making some reasonable assumptions about the variances of the measured outcome variables. Frequently, analytical error is insignificant compared with the population variance, σ^2, but, if not, one way to reduce θ^2 is to make multiple measurements on each sample.

Sampling for the purpose of estimating a mean differs from reconnaissance sampling in some important respects. For one thing, biased sampling of the target population is unacceptable because it will, in general, bias the estimate of the mean. This statement should not be taken to mean that the target population must be defined to be everything at the site. If the dominant risk scenario is inhalation of resuspended particulates, then contaminant levels in surface soils are of interest only for the finest fraction. However, the choice of the target population is dictated in this example by the risk assessment scenario, not by the fact that many contaminants adhere preferentially to the finer particles in soils and sediments. Neither does avoiding biased sampling mean that some subpopulations cannot be sampled preferentially using a stratified sampling plan (Section 5.2).

As a general rule, the larger the population variance, the more samples are needed to estimate a mean with given precision. Sections 5.1, 5.2, and 5.3 present sampling strategies that, correctly applied, can increase precision without increasing the number of laboratory analyses required. Reducing variance is not, by contrast, desirable for reconnaissance sampling, where the aim is simply to detect high levels of contamination, if present; therefore, the methods described in Section 5 have limited applicability in reconnaissance sampling plans.

Example

Reconnaissance sampling in the example of the former drum storage area described in Section 4.1.1 began with a site inspection and a radiological survey, whose results were to be used to bias subsequent sampling. If there are no positive results from these surveys, the investigator may select a representative sample at random from the surface soil of the PRS and could anticipate performing a baseline risk assessment using the mean values of the contaminants of concern identified by the screening assessment, if any. How precise will the estimates of these means be if based on the reconnaissance sample of size 11?

The fact that there were no positive field indications might be used to bound the concentration of some of the contaminants at the site and their variability as well. For example, if the radiological survey instrument should be able to detect ^{235}U concentrations above 20 pCi/gm in surface soil, it may be concluded that the average concentration at the site is below that level, and the standard deviation is unlikely to exceed half of this amount. (Distributions with coefficients of variation as large as 0.5 are very rare in nature, although they could occur at sites with small but highly contaminated hot spots.) Thus, the standard deviation of the mean of the proposed 11 samples should be less than $10\sqrt{11}$ or about 3 pCi/gm (assuming that the analytical error is negligible by comparison with 10 pCi/gm), which would allow estimating the mean with a 95% confidence interval not larger than ±6 pCi/gm (and probably a great deal smaller because the sample standard deviation is likely to turn out to be quite a bit less that 3 pCi/gm).

Background concentrations of ^{235}U are less than 0.1 pCi/gm, although an SAL based on a dose of 10 mrem/yr to a person who lived at this site (a very unrealistic scenario) would be on the order of 15 pCi/gm. Thus, an estimate of the mean to within ±6 pCi/gm, although not as precise as might be desired if the concentration of ^{235}U turns out to be well above background levels (greater than 5 or 10 pCi/gm, for example), should suffice for a preliminary baseline risk assessment in terms of incremental radiological dose to site workers or visitors. ❑

5.0 ENVIRONMENTAL SAMPLING STRATEGIES

The first three subsections below describe three strategies for reducing sampling variability when the goal of environmental sampling is to estimate population means. Another important objective for preliminary investigations is the estimation of variance components, and sampling for this purpose is the subject of Section 5.4. Finally, Section 5.5 provides a discussion of randomization.

5.1 Composite Sampling

One way to reduce sampling variability is to form composite samples. A composite sample is generally made up in the field. Grab samples [called "increments" in the statistical literature on composite sampling (Elder et al. 1980, 0795)] are collected as usual, following the appropriate procedures, except that less material may be required in each grab sample than if each were to be analyzed separately. The material from several grab samples is combined and homogenized to form a composite sample from which subsamples (seldom more than two) are removed and packaged as usual for laboratory analysis. Clearly, this brief description passes over some significant practical details. In particular, it is desirable that each grab sample

contribute an equal amount to the composite and to the subsamples, which suggests that any sieving to remove rocks and other debris should be done before the increments are composited. Homogenization should be as thorough as possible. If volatile contaminants are of concern, compositing should not be used.

In order to estimate the population mean from composite samples, the following assumptions are made:

- The estimate is computed as the average of $n = r \times s$ subsamples, that is, of the measurements on s subsamples from each of r composites.

- The volume of each composite is equal to that of S subsamples. (If $S = 1$, that is, if the entire composite is analyzed to produce one measurement per composite, then the middle term in Equation 5.1, below, can be ignored.)

- Each composite is formed from $m \geq 1$ grab samples. Equation 5.1 assumes that each grab sample is homogeneous; modifications could be made if this were not the case.

- σ^2 is the between-grab sample variability, usually more significant than any inhomogeneity within grab samples.

- τ^2 is the variance of the contribution of the individual grab samples to the measured subsamples. Ideally, each subsample has a contribution from each increment that went into its parent composite that is 1/n of the volume of the total subsample so that τ^2 is zero.

- θ^2 is the analytical error variance.

With these assumptions, the variance of the estimate of the mean is given by

$$\frac{\sigma^2}{rm} + \frac{m}{rs}\frac{S-s}{S-1}\sigma^2\tau^2 + \frac{\theta^2}{rs}. \qquad (5.1)$$

Thus, when the variability among grab samples is the major component of variance (that is, when σ^2 is much larger than either τ^2 or θ^2), its effect on the estimate of the mean of a population can be reduced by compositing.

Compositing is not generally appropriate for reconnaissance sampling, where population extremes are being sought. It could be appropriate for a situation such as that described in Section 4.1.2, which is actually a hybrid sampling strategy, a reconnaissance approach to preliminary baseline risk assessment. There, compositing would be done strictly within exposure units, which are the primary units sampled (selected using reconnaissance strategies) to improve the estimate of the mean within each exposure unit. Similarly, when compositing is done in combination with stratification, discussed in the next subsection, the increments to be composited are always selected from the same stratum.

5.2 Stratified Sampling

A second common method for reducing sampling variability partitions the domain into comparatively homogeneous strata, allocating a certain number of samples to each stratum (generally more samples to more variable strata.) It is assumed that there are J such strata, and N_j samples are allocated to the jth stratum. If the jth stratum accounts for a fraction F_j of the domain, then the appropriate estimator for the population mean is

$$\bar{x}_S = \sum_{j=1}^{J} F_j \bar{x}_j \ , \tag{5.2}$$

where $\bar{x}_j$ is the mean outcome for the samples in the jth stratum (computed as in Equation 4.2. Denoting the within-stratum variances by σ_j^2, this estimator has variance

$$\sum_{j=1}^{J} \frac{F_j^2 \sigma_j^2}{N_j} \tag{5.3}$$

(ignoring analytical error), which can be substantially smaller than the variance of the ordinary, unstratified mean if the σ_j^2 are small compared with the variability between strata. Often, of course, it is necessary to estimate the F_j from the data, which adds another, possibly significant, component of variance to Equation 5.3.

In a sense, a biased reconnaissance sample could be considered a stratified sample, but if one stratum (e.g., the stratum with no positive field indications) is not sampled at all, then the corresponding estimate of the mean (but not the sample maximum) has infinite variance, from Equation 5.3.

Example

Debris from several firing sites was formerly burned in trenches about 10 ft deep that had been excavated into the alluvium in a flat canyon bottom. The last of the trenches has now been backfilled and the entire area, less than one acre, has been leveled and reseeded. Although the bulk of the material brought to this site consisted of plywood and similar combustibles, this material may have been contaminated with small amounts of high explosive (HE), HE residuals, depleted uranium, and other heavy metals used at the firing sites. The screening assessment identified depleted uranium as the only contaminant of concern, which was observed in one sample from the thin layer of ash at the bottom of one trench.

The next step, therefore, is a baseline risk assessment. Step 1 of the DQO process identified as the most significant onsite exposure scenario exposure of individuals, who are making recreational use of the area, to material eroded from the trenches. Using this scenario, the mean contamination contained in the disturbed volume is estimated and used to calculate risk. The decision on whether to proceed to CMS or to propose no further action is based on the results of this baseline risk assessment.

The conceptual model for the site envisions a layer of ash and debris at the bottom of the excavated trench, which is covered by fill that might be slightly contaminated and is underlain by undisturbed alluvium into which contaminants may have leached. The area is investigated by drilling to a depth of a few feet below the bottom of the

pits. Contaminant levels in the ash and debris could be both significantly higher than in the other two strata and significantly more variable. Therefore, even though the ash and debris are probably only a small fraction of the total volume, the investigator will allocate more samples to those strata than to the fill and alluvium.

In this example, it is also necessary to estimate F_j for each stratum. The fractions of each stratum in each drill hole through the trenches (which can be observed independently of the selection of samples for laboratory analysis) can be used for this purpose:

$$\hat{F}_j = \frac{\sum_{h=1}^{N_{holes}} t_{hj}}{\sum_{h=1}^{N_{holes}} d_h}, \tag{5.4}$$

where t_{hj} is the number of linear feet of core through the jth stratum in the hth hole and d_h is the total length of core from the hth hole. If the thicknesses of the ash and debris strata are very variable, the variance given by Equation 5.3 will be significantly inflated.

Risk-based sampling (Seiler 1987, 0564) is a sampling strategy that deserves mention because it is designed to estimate not the mean contaminant level for the population but rather a weighted mean proportional to risk. It is a form of stratified sampling; the population to be sampled is stratified according to the degree of exposure associated with each unit. Thus, for a site at which dermal contact with soil is the main exposure route, those parts of the site that are currently exposed constitute one stratum, those imminently subject to exposure by erosion another, and more deeply buried areas are assigned to other strata. If these strata are then sampled in proportion to their contribution to receptor exposure potential, the (equally weighted) sample average of the observed contamination levels is proportional to the total risk posed by this contaminant distribution. ❑

5.3 Double Sampling

Double sampling, together with ratio or regression estimation of the population mean, is a third method for reducing the variance of the estimate without significantly increasing the number of expensive laboratory analyses required. The assumption is that there is one or more relatively inexpensive "fallible" measurement that is correlated (generally imperfectly) with more expensive "accurate" measurement(s) of the outcome variable of interest. If the fallible measurements are made on a large number N^* of samples from the population, and the accurate measurements are made only on a small subsample of size N, it may be possible to obtain a more precise estimate of the overall population mean by using both sets of measurements than by using the N accurate measurements alone. This estimate is calculated as

$$\bar{x}_R = \bar{x}_a + \hat{\beta}\left(\bar{x}_f^* - \bar{x}_f\right), \tag{5.5}$$

where $\bar{x}_a$ is the mean of the N accurate measurements, $\bar{x}_f$ is the mean of the fallible measurements on the same subsample of size N, $\bar{x}_f^*$ is the mean of all N^* fallible measurements, and β is the slope of the estimated linear regression of accurate on fallible values, based on the subsample. Equation 5.4 is called a "regression"

estimator for the population mean. Gilbert (1987, 0506) gives the formula for its variance in his Equation 9.2, which depends not only on the variability of the accurate and fallible measurements but also on the goodness of their correlation as estimated by the residual variance about the linear regression line. Gilbert also provides an extensive discussion of the conditions under which use of double sampling is cost-effective.

Theory or the empirical evidence of the linear regression may suggest that the linear regression actually passes through zero, that is, the accurate measurement is zero if, and only if, the fallible measurement is zero, in which case a slight modification of Equation 5.4, called a "ratio" estimator, is appropriate. Equation 5.4 can also be extended to the case in which a combination of two or more fallible measurements is available on the large sample.

Example

Following each shot at a former firing site, debris was bulldozed into a nearby arroyo to prepare the firing pad for the next shot. Use of the site had been discontinued by 1960, but a mound of unconsolidated debris, soil, and rock, several feet thick, remains on the side of the arroyo. One of three soil samples from the base of the mound at the edge of the arroyo channel, collected during a reconnaissance investigation, showed elevated levels of depleted uranium and a few other metals.

Given that depleted uranium is expected to be the only radionuclide present, field radioactivity measurements could be used to supplement analytical measurements of depleted uranium and other metals to improve the estimate of the mean contamination in this disposal area. Debris, as well as fill material, will be sampled, and regression estimators will be developed independently for each of these strata. For depleted uranium, a ratio estimator can be used. Concentrations of other metals may not be exactly proportional to radioactivity, so the more general regression estimator should be used. For these other metals, the correlation may not be good enough to improve the estimate of the mean over the estimate provided by the usual sample mean; however, because depleted uranium is the principal contaminant of concern, sample size may still be determined based on the ratio estimator for depleted uranium. ❑

5.4 Variance Estimation

Several of the formulas in the preceding sections indicate that the precision of the computed statistic, and hence the probability of error in testing a hypothesis and in making the resulting decision, depends not only on the sample size, which can be controlled by the investigator, but also on natural variability. The effects of natural variability can be partially controlled by using such techniques as stratification and compositing and by using accurate and precise analytical methods. However, natural variability is to some extent beyond the control of the investigator. Worse, there is often, at least initially, no basis for predicting the magnitude of natural variability. Therefore, one goal of most preliminary investigations is to collect enough data to estimate the important variance components. Exceptions may be made for limited investigations in cases for which neither baseline risk assessment nor formal CMS is anticipated. Accurate variance estimates are particularly important in designing a monitoring plan to meet regulatory requirements for site closure, conditional remedies, or deferred action.

5.4.1 Variance Components

Some of the specific components of variance that have appeared in the formulas above include

- the overall population variance,
- within-stratum population variances,
- subsample and between-aliquot variance, and
- error in analytical measurement.

Designing a preliminary study to estimate the magnitudes of these errors is similar to designing laboratory experiments. Balancing the design with respect to the factors of interest, avoiding a design in which two important effects are confounded, and including sufficient replication to distinguish measurement error and local heterogeneity from other variance components are important considerations. Field duplicates, splits, and other sample types that are built into a sampling plan for quality control purposes can be especially useful—field blanks and spiked samples provide a measure of analytical error; splits provide a measure of the sum of analytical error and the variance between subsamples or aliquots; and field duplicates provide a measure of the sum of analytical error, aliquot variance, and variance caused by local heterogeneities in the sampled medium.

5.4.2 Spatial and Temporal Covariance

The observation that things that are closer together (either spatially or temporally) are more likely to be similar than things that are farther apart has been called the first law of geography. One objective of a preliminary investigation may be to quantify this principle for the site under study. For example, the preceding sections present several formulas for the variance of an estimate, which are qualified by the phrase "assuming independent observations," but all of these formulas can be revised, if necessary, to accommodate correlated observations, provided that some estimate of correlation is available.

Many of the variables of interest in site remediation—contaminant concentrations, hydrogeologic variables such as permeability and mineralization, and population densities of biota—can be expected to be positively correlated, at least over short distances. Some variables, such as climate parameters, also have significant temporal correlations. For some forms of estimation, this correlation is not a drawback that invalidates the common expressions for variance but is an advantage that enables the investigator to predict with improved accuracy the spatial or temporal distribution of an outcome variable at unobserved points.

Although an estimate of spatial or temporal correlation can be formed given almost any reasonably well distributed sample from the population, a good estimate demands a little extra care. The optimal type of design for spatial covariance estimation is probably a radial grid with spokes (Flatman and Yfantis 1984, 0504) because this design provides a collection of collinear observations along four different axes and the opportunity to evaluate directional anisotropies as well as correlation as a function of separation. However, reasonable covariance estimates can be based on more uniformly distributed samples, provided care is taken to obtain

a little extra information for estimating the correlation on a scale that is small compared with the average sampling density. This small-scale variability is critical for estimating predictability.

Spatial or temporal continuity is modeled statistically using a spatial or temporal covariance function or variogram. Important features to quantify are

- the ratio of local (microscale) variability to global variability. Both field duplicates and samples that are closer together than average are essential for estimating this ratio.

- the correlation distance, defined so that observations separated by more than this distance in space or time appear to be uncorrelated. To perform this estimate, the data should contain several pairs of observations with approximately the same spacing for each of a number of different spacings.

- the overall (global) variability. There should be no difficulty estimating global variability, provided that the whole domain is reasonably well represented in the sample.

5.5 Randomization

Most statistical discussions of survey sampling, environmental or otherwise, recommend using some kind of randomization in selecting samples. The arguments in favor of randomization are both theoretical and practical. Classical, "design-based" theories of estimation from survey data assume that samples have been selected randomly, although possibly with constraints such as allocation of a certain number of samples to different strata or a minimum spacing between samples. There are other approaches to sampling theory, but they do not currently enjoy such widespread acceptance as the design-based approaches, either among regulators or among academic statisticians. In any case, the practical considerations still apply.

The practical argument for randomization is that it should result in a more "representative" sample of the whole population, unbiased either consciously or unconsciously by the judgment of the investigator. Thus, extrapolation of results from a small sample to the whole population is a more satisfactory procedure than it would be if the sampling locations were selected at the whim of the investigator, no matter how objective he/she might be.

The reasons for not using randomization in the field also appear to be practical—sites chosen at random often turn out to be unsuitable for sampling for one reason or another (too rocky, underneath a concrete pad, next to a beehive, etc.), and it is more time-consuming to survey in random locations than to survey a regular grid. EPA has many practical suggestions for overcoming these objections (EPA 1989, 0794, Chapter 5).

One of the simplest randomization schemes is to use a regular grid, randomizing only the starting point and the orientation. [This scheme does not meet all the requirements of design-based sampling (Iachan 1982, 0507), but it does at least generate a sample whose objectivity should be beyond question.] Additional randomization, rather than the judgment or convenience of the field team, should be used to replace a grid point that turns out to be unsuitable for sampling. There are also simple methods for randomizing every sampling location starting from a surveyed grid that

can be applied on the spot by a field team equipped with nothing more elegant than a pair of dice (or any similarly low-tech method for generating random numbers), a compass, and a tape measure.

6.0 STATISTICAL CONSIDERATIONS FOR FOLLOW-UP INVESTIGATIONS

Once a partially quantitative conceptual exposure model has been built, together perhaps with a quantitative decision model, the design of follow-up data collection activities is strongly dependent both on the model and on the stage in the decision flow. This section discusses in general terms some sampling and data analysis options that can be useful in such follow-up studies but that would not be appropriate for a preliminary investigation.

6.1 Prediction Approach to Sampling and Estimating

An alternative to design-based sampling views the problem as one of predicting the outcomes that would been observed for the unsampled units by using data to construct a statistical model for the outcome variables. This approach goes by various names in the statistical sampling literature—"model-based sampling," "prediction approach"—but is philosophically distinct from the more widely accepted design-based approaches that have been implicit in almost all of the discussion so far. (Regression estimates, discussed in Section 4.6, have a prediction flavor, but are nevertheless widely used even by statisticians who reject other model-based approaches.)

Models used in the prediction approach usually incorporate *auxiliary variables*, which are known or are easily measured for the entire population of interest. [Stratification is another way to use auxiliary variables: the population is partitioned into substrata based on the values of auxiliary variables such as the media type (soil, sediment, tuff, decaying vegetation) or provenance (ash, debris, or fill, in the burning pit example).] One type of auxiliary variable that is always available in environmental work is location, two or three spatial coordinates, and possibly a time coordinate as well. The first law of geography, cited at the beginning of Section 5.4.2, suggests that these spatial and temporal variables should not be ignored in environmental work, and some prediction approaches to sampling and estimation (such as, in particular, kriging) are explicitly designed to exploit them (Cressie 1991, 0793).

In design-based sampling, the probabilistic structure that relates the observations to the population was introduced by modeling the sampling process itself, and, therefore, randomization of that process (Section 5.5) is a key concept. In model-based approaches, the probabilistic framework is introduced by means of a statistical model for the population. Of course, introducing a statistical model does not preclude randomizing the sampling plan. In application, model-based sampling must be concerned with the ability of the procedures to withstand deviations from the postulated models and can use the ideas of design-based sampling, including randomization, as safeguards against such departures (Little 1983, 0509).

The statistical form of the models used for prediction approaches to sampling and estimation is the "mixed effects" model. The "fixed effects" in this model represent trends in the outcome variable with respect to the auxiliary variables and also provide a mechanism for modeling other aspects of the process generating the observations, such as integration over some volume by compositing or by field instrumentation. This part of the model usually includes unknown parameters (at least a population

mean), whose estimation is one goal of data analysis. The second part of the model, the "random effects," are represented only by a covariance structure that is patterned, i.e., is a function of auxiliary variables and a few parameters.

The idea of the prediction approach, then, is to (1) use sample observations to estimate the parameters of both the patterned covariance structure and the trend component, (2) use the resulting model to predict the unobserved outcome variables, and finally (3) estimate population parameters of interest (the global mean, local means, or other functionals of the population outcome variables) by applying the corresponding functionals to the combined observed and predicted outcomes. Ideally, estimation of the covariance structure is based on data from a preliminary survey, as discussed briefly in Section 5.4.2, because this information is needed to design an appropriate follow-up sampling and analysis plan. In practice, the same data are often used for both Steps 1 and 2.

The advantage of model-based estimation is that estimators for functionals of the population other than the global mean are easily constructed. In particular, the use of model-based procedures is almost essential for estimating the means of many small subpopulations, e.g., averages over many small exposure units. The design-based alternatives require a large number of samples and enough observations in each subpopulation to estimate its mean independently of the rest of the data. Although such large samples may be necessary to verify site cleanup, they are inappropriate for site characterization in the RFI phase.

Example

This example is a simplified version of the Bayo Canyon firing site, discussed in much more detail in the RFI Work Plan for OU 1079 (LANL 1992, 0783).

A large canyon-bottom area included several firing points in which shots containing small amounts of radioactive materials were fired. During the 1960s, the site was sampled under the DOE's Formerly Utilized Sites Remedial Action Program (Mayfield et al. 1979, 0818) and some cleanup was done. As a result of this work, there is a good data base for radioactive contamination but not for other possible contaminants, particularly metals. The site is close to existing residential areas and is potentially suitable for residential development.

A baseline risk assessment that uses a residential exposure scenario is planned for this site, which implies that it is necessary to estimate average contamination levels over rather small exposure units (each less than 1/5 acre in size, of which several hundred are within range of the former firing points), and to make decisions about whether to clean up or to investigate further on a unit-by-unit basis. New environmental data (metals, HE, and by-products) are needed to supplement existing radionuclide data.

Large "false negative" error rates cannot be tolerated for this public area. Fortunately, both the conceptual model and the existing data suggest a fairly continuous distribution of contaminants around the firing points, which can be exploited in the design of a sampling plan. Because the site is so large, the proposed approach is to use kriging to predict contaminant levels in exposure units, which requires fewer than one observation per exposure unit if the contaminant distributions are as continuous as suggested by the existing data (LANL 1992, 0783). A design-based approach to this problem would require a minimum of one composite sample per exposure unit. The reconnaissance approach of the example in Section 4.1.2 might also be used if a two-phase RFI were considered acceptable. ❑

6.2 "Hot Spot" Sampling

At some point during the RCRA process, it may be necessary to define the problem as one of locating small but highly contaminated areas or volumes. The only known approaches to this problem are very resource-intensive unless inexpensive yet effective field survey methods are available.

Sampling designs for this "hot spot" detection problem are usually based on regular grids (typically rectangular or triangular; the latter are somewhat more efficient). The grid spacing is determined by specifying the desired probability for detecting a contaminated area as a function of its size. Gilbert (1987, 0506, Chapter 10) discusses the determination of grid spacing, including several nomograms for determining the probabilities of detection and one graph that can be used for cost/benefit analysis.

Grid spacings must be comparable to (within about a factor of two) the radius of a contaminated area in order to have a reasonably high probability of detecting that area, and, therefore, very fine grids are required if small hot spots are of potential concern. The necessity of very fine grids limits the appropriateness of hot-spot sampling for RFI work. However, the technique has more utility during CMS and CMI, when the area under consideration has been better delineated and it becomes important to minimize the amount of unnecessary remedial work.

6.3 Determining What Fraction of a Site Is Contaminated

Reconnaissance sampling is the simplest form of a nonparametric approach to the problem of estimating the proportion of a site that exceeds an action or cleanup standard. In later phases of the RCRA process, particularly in verifying the attainment of cleanup standards, more data may be collected, and more efficient tests, in particular, tests that control the probability of false positives as well as false negatives, can be devised. Several such tests, including sequential versions that could be applied during site cleanup, are discussed in EPA guidance (EPA 1989 0794, Chapters 7 and 8).

One approach, similar to reconnaissance sampling, consists of "coding" each observation as a "1" or a "0, "depending on whether the observation exceeds the specified standard. The test statistic is then the sum of these codes, which is just the number of "exceedances" of the standard in the total sample of size N. If the proportion of zeros is sufficiently large, the site can be considered acceptably clean, even if there are some ones in the sample. This approach typically requires 30 to 100 observations (EPA 1989, 0794, Tables A.7, A.8, and A.9), depending on acceptable bounds of error.

The second approach, which requires making an assumption about the form of the probability distribution of the outcome variable (e.g., normal, log-normal), is to estimate a confidence interval for a percentile of this distribution. For the tail percentiles that are usually of interest (often the 90th or above), the correctness of the assumption is critical, so use of this method must be preceded by a test of the assumption, something that also requires a substantial number of observations (several tens, at least.)

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■ APPENDIX I

Decision Strategies for Environmental Restoration

1.0 INTRODUCTION

As described in Section 1 of this Installation Work Plan (IWP) for Environmental Restoration (ER), the Hazardous and Solid Waste Amendments (HSWA) Module of the Los Alamos National Laboratory's (Laboratory's) permit to operate as a treatment and storage facility (EPA 1990, 0306) specifies a three-step corrective action process: the Resource Conservation and Recovery Act (RCRA) facility investigation (RFI), the corrective measures study (CMS), and corrective measures implementation (CMI). At each step, there are a number of alternatives for action at a potential release site (PRS) or for gathering more information about contamination at a site. Choices among the alternatives are difficult because of uncertainty from many sources and because of the existence of multiple stakeholders, multiple goals, and strict regulatory requirements.

This appendix discusses the overall decision process, together with formal procedures that can aid the selection of strategies in this complex situation. In particular, this appendix describes decision analysis as a supporting and integrating tool. Decision analysis is a philosophy, a theory, and a set of practical procedures for decision making. It provides a systematic method grounded in a set of widely accepted, formal axioms for quantifying sources of uncertainty, defining scales for measuring outcomes, quantifying the value of different decision strategies, and identifying optimal decisions based on multiple objectives.

1.1 Overview

Four factors contribute to the difficulties that arise while structuring and evaluating RCRA corrective decisions in the ER Program at the Laboratory. One factor is the number and diversity of stakeholders in the cleanup process, including regulatory agencies, Laboratory employees, and the public. A second factor is the significant uncertainties that result from incomplete information about historical activities at the site, changing physical characteristics of the site, incomplete understanding of the health impacts of contaminants, inexact forecasts of future uses of sites, and other influences. Even with the best mathematical and computer models to forecast the current state and long-term fate of contaminants, these uncertainties cannot be eliminated completely. A third factor is the existence of multiple objectives for the cleanup effort. Public and worker health and safety must be protected, ecological systems must be preserved, costs must be held at a responsible level, facility operations must be maintained, and socioeconomic impact must be minimized. Finally, the decision process must be structured to meet RCRA regulatory criteria.

The RCRA permit regulates not only the physical waste site but also the process of making decisions regarding the waste site. The RCRA permit for the Laboratory states that "The Permittee shall prepare a plan to ensure that all information, data, and resulting decisions are technically sound, statistically valid, and properly documented." According to the RCRA permit, the process of identifying corrective actions must consider "site-specific objectives for the corrective action...based on public health, the environment, information from RFI, EPA (Environmental Protection Agency) Guidance and the Federal statutes" and must review "a workable number of options that each appear to adequately address all site problems and objectives." The RCRA permit further states that the program must describe the "alternatives and tradeoffs among the evaluation criteria."

In summary, the decision process must be logically sound and consistent. It must support the generation, evaluation, and recommendation of alternatives in light of program objectives, as well as account for multiple stakeholders, multiple evaluation criteria, uncertainty, and risk. This appendix reviews the decision tools available to help the ER Program at the Laboratory meet these requirements.

1.2 The Corrective Action Decision Process at the Laboratory

Figure I-1, a diagram of the RCRA corrective action process, illustrates the general decision flow and the decision alternatives for the RFI/CMS/CMI process, including the possibilities for action and for gathering and evaluating information throughout the decision-making process. Each rounded rectangle in this diagram describes an information-gathering or PRS treatment action in the decision process. Each diamond represents an information evaluation point. The arrow to each action is labeled by a description of the information evaluation result that leads to that action.

In general, the corrective action process moves from the actions in the upper left-hand corner to those in the lower right-hand corner. The starting point of the general decision diagram is the archival information node. After reviewing the archival information, the decision maker(s) may decide to proceed immediately to one of the final actions, that is, to take no further action (NFA) under the ER Program, to defer action, or to remediate based on available information. The criteria for NFA and deferred action are explained in more detail in Section 4.1 of this appendix. Voluntary corrective action (VCA) (remediation without conducting a formal CMS) is appropriate when the site may pose a hazard, when the corrective measure is obvious, and when it is less expensive to remediate than to undertake a complete site characterization.

Archival information is usually not sufficient to select one of the alternatives listed on the right-hand side of Figure I-1, and the decision maker most often proceeds with further characterization of the site. RFI site characterization usually proceeds in several phases and, once the site is sufficiently well understood, leads to a baseline risk assessment. The RFI site characterization and risk assessment then lead to one of the options for action already considered or to a formal CMS to select and design the most appropriate and effective corrective action. Site characterization may continue into the CMS and CMI phases of the RCRA process, although the later data collection activities focus on site characteristics that affect particular corrective measures.

In summary, each information evaluation during the RFI has the potential of leading to a treatment action (NFA, deferred action, or remediation), of jumping ahead to a later stage of information gathering, or returning to an earlier stage of information gathering. This decision- making approach permits economy in gathering information and flexibility in the response to new information.

2.0 DECISION SUPPORT TOOLS FOR THE ER PROGRAM

The Laboratory's streamlined approach for environmental restoration consists of the coordinated use of a set of decision tools, including data quality objectives (DQOs), risk analysis, and decision analysis, to implement the observational approach described in Appendix G. DQOs and risk analysis are described in detail in Appendices I and K, respectively. They are reviewed briefly in this section in order to discuss their integrated use and how decision analysis supports their use.

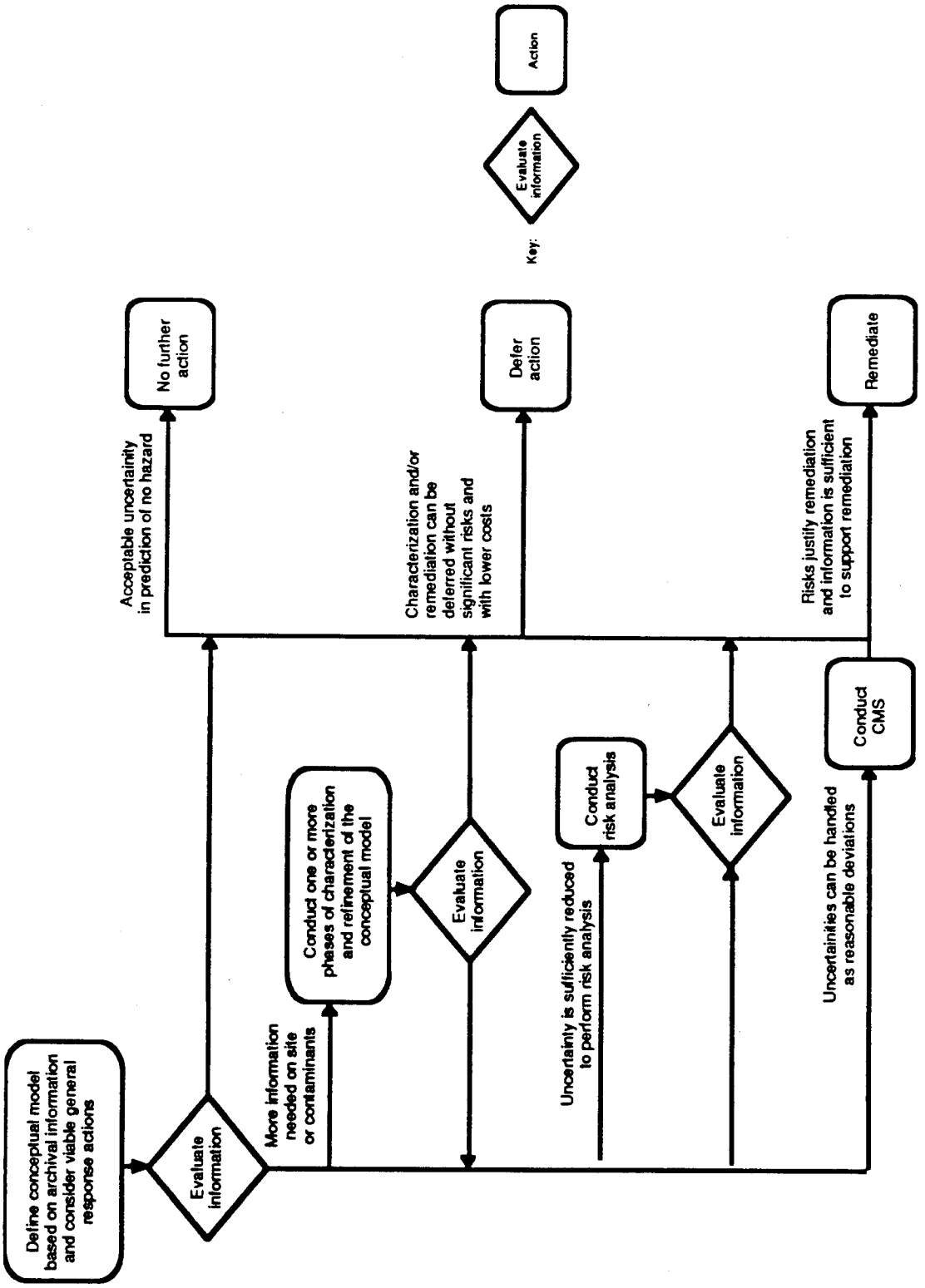


Figure I-1. General decision flow and decision alternatives for the corrective action process.

Decision analysis and its applications are then described in more detail in Section 3.

The observational approach, which provides the rationale for the streamlined approach to environmental restoration, recognizes the uncertainties inherent in the many decisions that must be made during the process of environmental remediation and the impossibility of completely eliminating uncertainty. It emphasizes that complete information is an unreasonable goal; information should be gathered only to the extent necessary to make a specific decision and to move forward in the remediation process. In particular, the observational approach advocates the phased collection of information, not only during the RFI but also during the CMS and CMI. Phased collection of data helps ensure that unnecessary data are not collected and that the level of detail specified for each data collection activity is appropriate for the current stage of the RCRA process. It promotes decision making that is neither premature nor delayed and demands efficient, adaptive decision making.

The DQO process is a series of steps leading from the definition of a contamination problem and a set of decision alternatives through the formulation of an appropriate hypothesis about the site to the design of a sampling and analysis plan that provides data to test the hypothesis. Using this approach, the investigator bases intermediate sampling decisions (e.g., the number of observations and analytical precision required) on explicit definitions of "acceptable" uncertainties for each decision. Because the DQO process links sampling decisions to a specific remediation decision and develops the most cost-effective sampling plan to resolve a problem satisfactorily, the process is a useful tool for implementing the observational approach.

Risk assessment is the determination of the human health and environmental risks imposed by contamination. Risk assessment considers (1) pathways through the environment that contaminants might follow to reach potential receptor populations, (2) possible land uses and receptor activities at the exposure points, (3) exposure routes (e.g., ingestion, inhalation), (4) the toxic properties of materials, and (5) the health and environmental impacts of contaminants. The outcome of a risk assessment is both an evaluation of the risks posed by a contaminated site and an understanding of the physical factors that create those risks. Risk assessments help to implement the observational approach by allowing decisions to consider the impact of contamination at a site as well as the level of contamination.

Decision analysis is a formal, quantitative process for structuring, analyzing, and communicating decisions in complex, uncertain environments. Decision analysis breaks the decision into components and structures the components in a decision model. The decision model logically integrates what one can do (decision alternatives), what one knows and does not know (uncertainties), and what one wants (values). Once created, the decision model can be exercised to provide insights and directions for action.

Decision analysis directly supports the observational approach by calculating the value of progressively reducing uncertainty when evaluating alternatives. To do this, decision analysis first defines a single measure of value based on multiple decision criteria, including health and safety, environmental impacts, managerial concerns related to operations and compliance, public concern, and cost. This value measure can be used not only to evaluate the decision alternatives but also to determine the value of additional information, taking into consideration the losses caused by making a bad decision, the current likelihood of choosing the best decision, and the improvement in that likelihood that may be obtained by gathering more information.

Decision analysis supports the DQO process by developing definitions of the value of additional information and accuracy. The value of information provides a basis for determining the appropriateness of different "discomfort curves" and "acceptable" errors used by DQOs in sampling design.

Decision analysis supports risk assessment by helping to integrate health and safety risks with other measures of benefits and costs. Decision analysis can also provide tools for developing estimates of uncertainties relevant to risk assessments and for calculating risks in complex situations.

3.0 OVERVIEW OF DECISION ANALYSIS

Decision analysis is a widely accepted approach for analyzing major public policy issues that has been used by government agencies, including DOE, EPA, and the Department of Defense, and by many individual DOE facilities to address a great variety of problems. In the ER Program, it offers a framework for a consistent and efficient installation-wide RFI/CMS/CMI process, as well as tools for addressing problems in individual operable units (OUs). It provides a set of procedures for assessing and analyzing decision alternatives that takes into account the experience, knowledge, and objectives of the decision maker(s) and the risks present in the decision. Basic references on decision analysis include Making Hard Decisions: an Introduction to Decision Analysis (Clement 1991, 0808) and Decision Analysis (Raiffa 1968, 0812).

Figure I-2 is an illustration of a very simple decision model. The decision alternatives, shown on the left side of the diagram are to remediate or not remediate the site. There is one uncertainty: whether the site is contaminated or not contaminated. As shown in Figure I-2, the best information currently available has led to the belief that the probability of contamination is only 0.01 (a probability of 0.99 that the site is not contaminated). Values are listed at the far right. In the following sections, the process for constructing and using such a model is discussed.

3.1 The Decision Analysis Process

The cycle for developing and using the decision analysis model consists of five basic steps. (The process is referred to as a cycle because frequently the result of one pass through the steps outlined below is a decision to gather more information or to create a new alternative and then reanalyze the problem.)

1. Problem Formulation

   In the problem formulation step, the decision maker (or decision team) defines the decision problem and lists the decision alternatives, reviews the uncertainties that complicate decision making, and describes the objectives guiding the decision (objectives are quantified through values later in the cycle). The result of this step is a conceptual (i.e., not yet quantitative) version of the decision model. The conceptual decision model behind the tree in Figure I-2 has the following components:

   - decision problem: should the site be remediated?
   - decision alternatives: remediate or do not remediate the site;

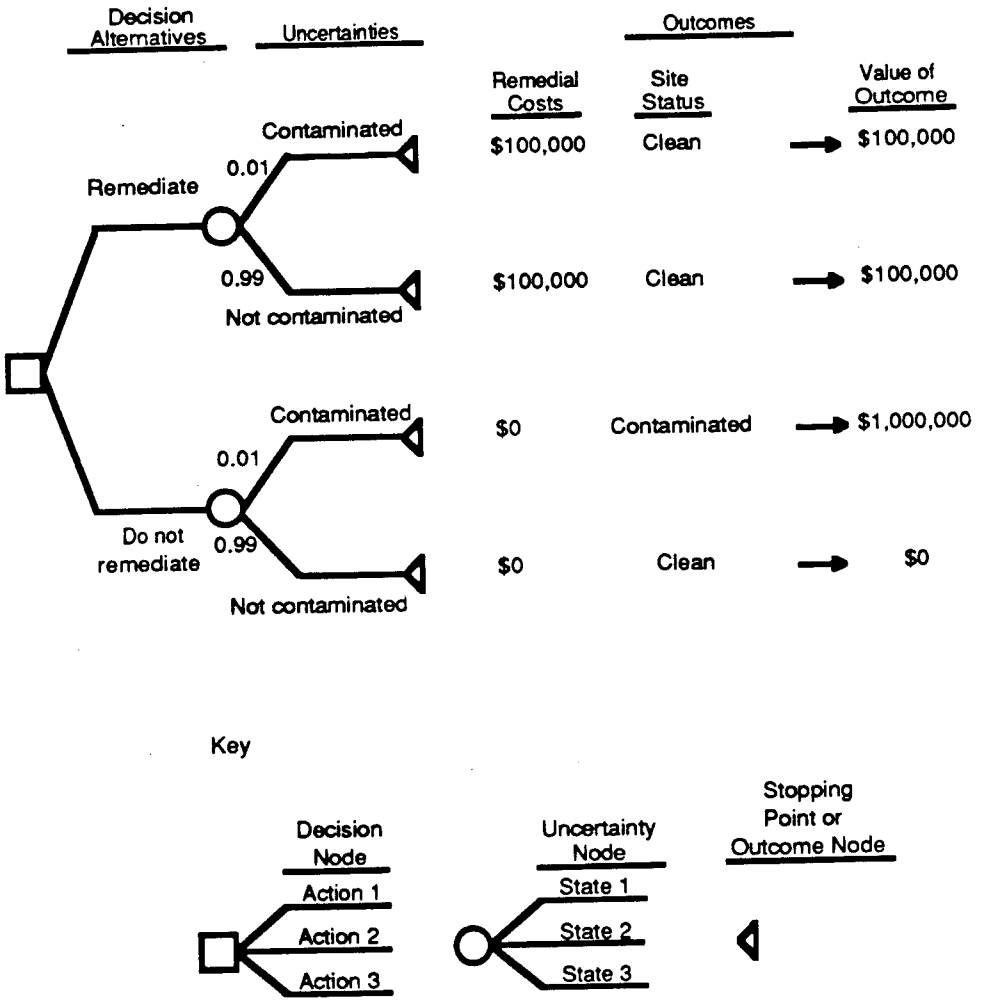


Figure I-2. Simple Decision Tree.

- uncertainties: whether the site is contaminated;
- objectives: minimize health risk and minimize costs.

More general decision alternatives that arise in the course of the RCRA process are enumerated in Section 3.2 below. Programmatic objectives are discussed in Section 3.3. Section 3.4 presents a generic conceptual decision model that could be applied in the ER Program.

2. Deterministic Modeling

The deterministic model computes a single value for each combination of decision alternatives and uncertainty states (a state is a particular resolution of an uncertainty). Figure I-2 shows four such combinations, each corresponding to one state of the uncertainty (whether the site is contaminated) and one decision alternative (remediate or do not remediate). The deterministic model can be further broken down into structural models that may determine multiple final outcomes and value models that determine a single value for each combination of final outcomes.

A structural model calculates an outcome that follows from the selection of each of the alternatives, given the states of the uncertainties. For example, in a financial analysis, the structural model might include statements such as "profits equal revenues minus costs." For the example in Figure I-2, the structural models are contained in the following four statements:

- Remediating the site costs $100,000.
- Not remediating the site costs $0.
- Contaminated sites that are not remediated have high human health effects.
- Uncontaminated sites and contaminated sites that are remediated have low health effects.

In the ER Program, structural models needed for corrective action decisions include, at a minimum, a cost model and a risk assessment model; that is, there are at least two types of final outcomes—dollar costs and human health effects—that must be modeled. There may also be structural models for environmental impacts or other final outcomes of importance.

The value model provides a single measure of value for any set of final outcomes. In ER Program decisions, the value model is particularly important because of the many disparate final outcomes of concern, such as dollar costs and human health effects. Multiattribute utility analysis (Keeney and Raiffa 1976, 0809) is the technique used by decision analysis to construct value models that can balance in a logical, defensible way the multiple final outcomes of concern to the ER Program. Tools used by multiattribute utility analysis to support value modeling are objectives hierarchies. These hierarchies link top-level, general objectives to more detailed and concrete objectives and scales, which are detailed descriptions of uncertainties or final outcomes.

The objectives hierarchy for the example in Figure I-2 consists of two objectives: minimize health risk and minimize costs. One simple, defined value scale appears in the example. It describes the final health risk outcomes and has two states: low and high health effects. In an actual study, value scales would be defined in much more detail.

The value model in the example is straightforward. The model assigns a value of one unit to each dollar spent, zero unit to low health effects, and one million units to high health effects. The single value (actually a "cost" in this example, which is something to be minimized, not maximized) associated with each set of final outcomes is shown in the right-hand column of Figure I-2. The tools for value modeling are discussed further in Section 3.3.

Deterministic models are often used for "what if" analyses, in which uncertainties are set to a wide range of states so that their impact on the final outcomes can be examined. When final outcomes are minimally affected by a particular uncertainty, that uncertainty may be fixed at a single state and thus may be given less attention in later stages of the analysis.

3. Probabilistic Modeling

In the probabilistic modeling step, the descriptions of important uncertainties in the decision model are expanded to probability distributions over their possible states. When historical or experimental data are available, they can be used to help specify appropriate distributions. In other cases, probabilistic descriptions rely on the opinions of unbiased experts. Decision analysis offers both formal and informal procedures for eliciting these probabilities from experts (Merkhofer 1987, 0811), and a number of computer programs have been developed for recording, combining, and analyzing the probability information gathered in this step.

The one uncertainty in the example is whether the site is contaminated. The probabilistic model assigns probabilities of 0.01 that the site is contaminated and 0.99 that the site is not contaminated.

4. Value-of-Information and Other Analyses

In this step, a number of analyses can be performed by exercising the fully quantified (probabilistic) decision model. These analyses include

- determining the best decision based on current information,
- estimating the probable value of gathering more information,
- describing a "risk profile" that indicates the probability of occurrence of each possible final outcome,
- analyzing the sensitivity of the optimal policy to uncertainties in the model, and
- determining the value of controlling an uncertain variable.

In the example, the expected value of each decision can be calculated and used as a guide to decision making. Expected value is calculated by multiplying the value associated with each set of final outcomes by the probability of that set and summing the weighted values for each alternative. The calculations are as follows:

For "remediate site": (0.01 x 100,000) + (0.99 x 100,000) = 100,000.

For "do not remediate site": (0.01 x 1,000,000) + (0.99 x 0) = 10,000.

According to this analysis, the probability and value (cost) of high health effects are too low to justify cleaning the site.

The value of perfect information on site contamination can also be calculated in the decision model. If it is known that the site is contaminated, the site should be cleaned, with a resulting value (cost) of 100,000. If it is known that the site is not contaminated, the site is not to be cleaned, with a resulting value (cost) of 0. The expected cost with perfect information is the sums of the costs of responding to each state times the probabilities that each state will occur:

Expected value (cost) with perfect information: (0.01 x 100,000) + (0.99 x 0) = 1,000.

The value of perfect information is the difference in the expected values with and without perfect information:

Value of perfect information: 10,000 - 1,000 = 9,000.

The value of perfect information is the maximum that should be paid for information gathering. In this case, if the value (cost) units can be interpreted as dollars, the cost is no more than $9,000.

5. Decision

The final step of the decision analysis cycle is to make and communicate a decision. It is especially important to present the results and insights gained from the analysis clearly in order to back up the recommended action. Decision analysis uses graphical devices such as influence diagrams, decision trees, sensitivity charts, and risk profiles to facilitate communication of the decision.

3.2 Decision Alternatives in the ER Program

This section provides a list of the decision alternatives in each step of the ER Program.

3.2.1 RFI Decision Alternatives

The RFI step of the corrective action process is defined to include decisions made when planning the RFI, decisions made at the conclusion of the RFI regarding future action at the site, and the intermediate decisions on sampling or action at the site.

After archival review, four main alternatives exist for the RFI work plan:

- based on archival information, propose NFA;
- propose deferred action;
- propose VCA, with or without a very limited RFI investigation;
- proceed with a CMS;
- propose a Phase I investigation.

If NFA or deferred action is chosen, few additional decisions need to be made at this point. The alternatives, CMS and VCA, are described in Sections 3.2.2 and 3.2.3, respectively. In the event that a Phase I investigation is chosen, a number of additional sampling decisions must be made, which include

- whether the objective of Phase I is to determine

- presence or absence of contamination (e.g., in support of a proposal for NFA),
- extent of contamination (e.g., in support of possible VCA or eventual CMS),
- average level of contamination (e.g., in support of eventual baseline risk assessment), or
- offsite migration (e.g., in support of a proposal for deferred action);

- whether site-specific hydrogeologic or other properties of the environment need to be measured at this time (e.g., to characterize environmental transport pathways for assessment of risks to offsite receptors);
- what media to sample;
- what sampling techniques to use;
- what parameters to measure;
- what analytic methods to use;
- how many samples are needed; and
- where samples should be placed.

Phase I investigation is followed by evaluation of all information to select, if possible, one of the action alternatives (NFA, deferred action, VCA) or to select an information-gathering alternative (further characterization, risk analysis, or CMS). Frequently, several phases of site characterization occur during the RFI. The RFI ends when an action alternative (NFA, deferred action, VCA, CMS) is chosen and the extent of contamination is sufficiently understood to support baseline risk assessment and/or CMS, as required.

3.2.2 CMS Decision Alternatives

It is expected that less than 5% of PRSs will require a CMS/CMI. The CMS step of the corrective action process includes both the decisions made in planning the CMS and the decisions concerning the selection of a corrective measure for implementation.

The CMS plan must propose ways of evaluating corrective action alternatives for the site. The following categories of decisions are among those that need to be addressed when planning the CMS:

- whether additional site or contaminant characterization is needed to select and design an appropriate corrective action,
- which corrective methods and land uses should be considered in feasibility studies,

- what level of detail is appropriate for the feasibility studies,
- which corrective actions should be evaluated by bench- and pilot-scale tests,
- which corrective actions should be addressed by detailed engineering evaluations,
- for which potential deviations from probable site conditions should contingency modifications of the selected corrective action be developed, and
- what the schedule will be for conducting the CMS.

During the CMS, many corrective measures alternatives are available, including various combinations of monitoring, containment, in situ treatment, removing contaminants (with treatment and disposal options), and land use restrictions (Section 4.6). The CMS concludes with formal definition of cleanup standards and the selection and design of a corrective measure to attain these standards, together with contingency plans that can be implemented if deviations from expected site conditions materialize.

3.2.3 CMI Decision Alternatives

This step implements the selected corrective measures. However, given the uncertainties that may still exist, several decisions will remain to be made, including

- whether an observed deviation from expected site conditions is sufficient to warrant implementation of one of the contingencies to the planned corrective action;
- when implementation of the selected corrective measure is complete, i.e., whether the planned cleanup levels have been attained;
- whether all dangerously contaminated material has been removed;
- whether containment barriers have been sufficiently extended; and
- whether the long-term effectiveness of the implemented corrective measure meets expectations.

3.3 RCRA Evaluation Criteria

The values of the decision maker are incorporated in the decision process through an objectives hierarchy and scales that allow measuring a state or the level of a final outcome. A suggested objectives hierarchy for the Laboratory is shown in Figure I-3. The top level of the hierarchy is a list of key concerns for evaluating alternative corrective measures (Section 4.3). Lower-level objectives identify the specific aspects of the higher-level objectives. The future performance of corrective

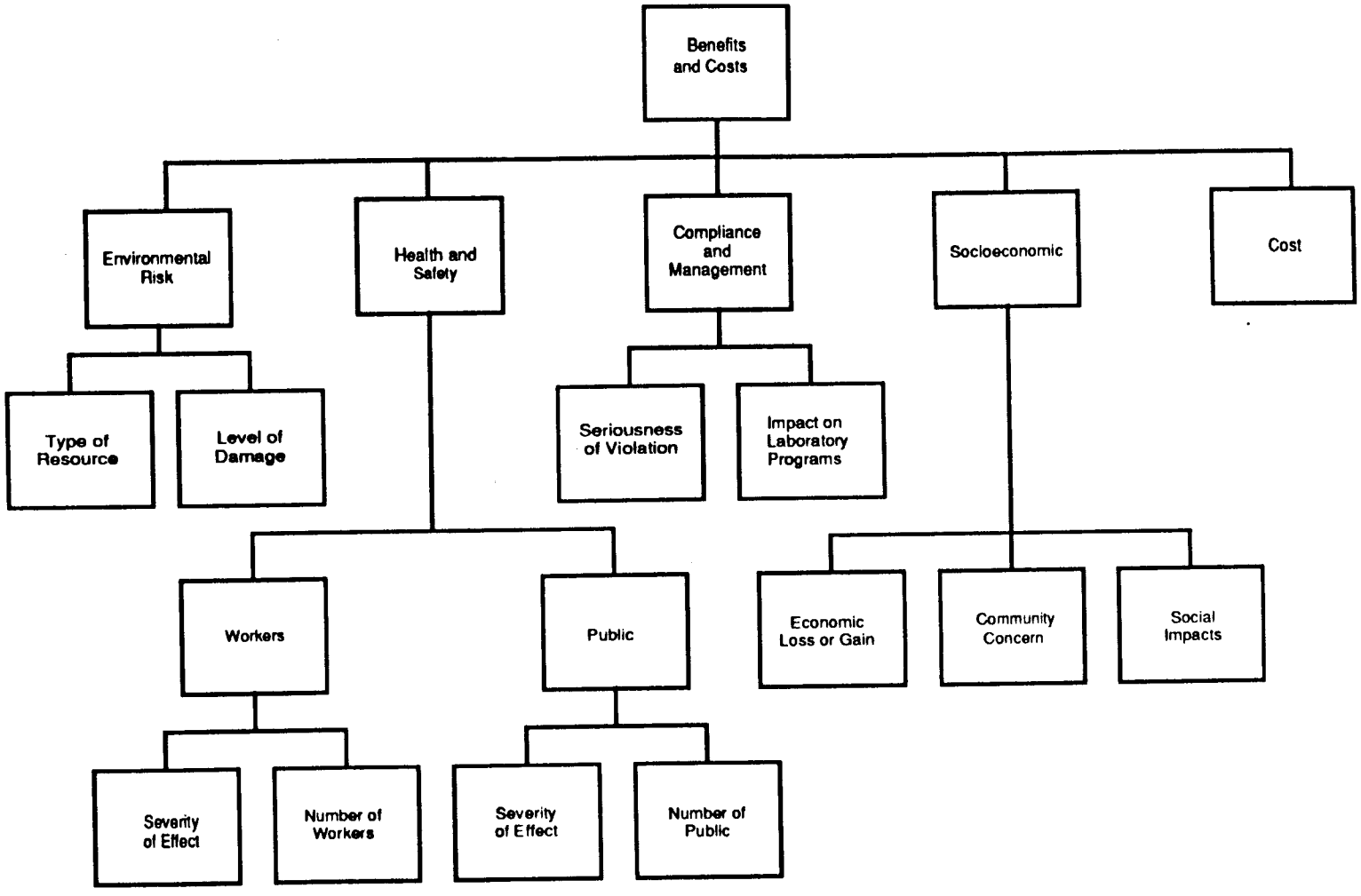


Figure 1-3. Objectives Hierarchy.

measures alternatives under consideration can be evaluated using scales that reflect the lowest-level, most concrete objectives.

The hierarchy shown in Figure I-3 is based on hierarchies developed to support the Laboratory's response to the Department of Energy's (DOE) Tiger Team findings (LANL 1992, 0810) and the prioritization of ER Program activities. Personnel throughout the Laboratory were interviewed individually and collectively over several months to develop these hierarchies. The hierarchies were reviewed by the Environment, Safety, and Health Council, other Laboratory managers, the ER Program manager, a set of OU project leaders (OUPLs), ER Program technical team leaders, and other ER Program personnel. The objectives reflect the major concerns identified in the RCRA operating permit, the IWP, and relevant federal regulations, as well as issues important to Laboratory operations.

To be able to use the objectives hierarchy in evaluating outcomes, scales must be developed that allow decision makers to clearly describe final outcomes. In some cases, natural scales exist. For example, dollars is a natural scale for communicating outcomes involving costs. In other cases, natural scales do not exist and artificial scales must be created. As an example, the following scale for measuring community concern might be used.

Level 1 The waste unit generates no public concern for the following reasons:

- People are not aware of the waste unit or of any problem that includes the waste unit other than the Laboratory as a whole.
- People are aware of a distinct problem but do not have any special concern beyond their concern about the Laboratory as a whole.

Level 2 The contaminated unit generates some public concern for any of the following reasons:

- There are occasional (several per year) news stories about the problem in the media serving the Los Alamos area, and the problem is discussed at community meetings.
- Claimed economic impacts on the community or on the Laboratory are less than $100,000 total or $10,000 annually.

Level 3 The contaminated unit generates moderately high public concern for any of the following reasons:

- There are monthly news stories about the problem in the media serving the Los Alamos area and occasional news stories in national media.
- The problem is frequently discussed at community and

local government meetings.

- Claimed economic impacts on the community are less than $100,000 total or $10,000 annually.

Level 4 The contaminated unit generates very high public concern for any of the following reasons:

- There is frequent (more frequent than monthly) negative national news coverage about the problem and there have been large-scale protests.

- Claimed economic impacts on the community total on the order of $1,000,000 or more or $100,000 annually.

The NFA and deferred action criteria presented in Section 4.1 of this appendix illustrate a practical application of scales.

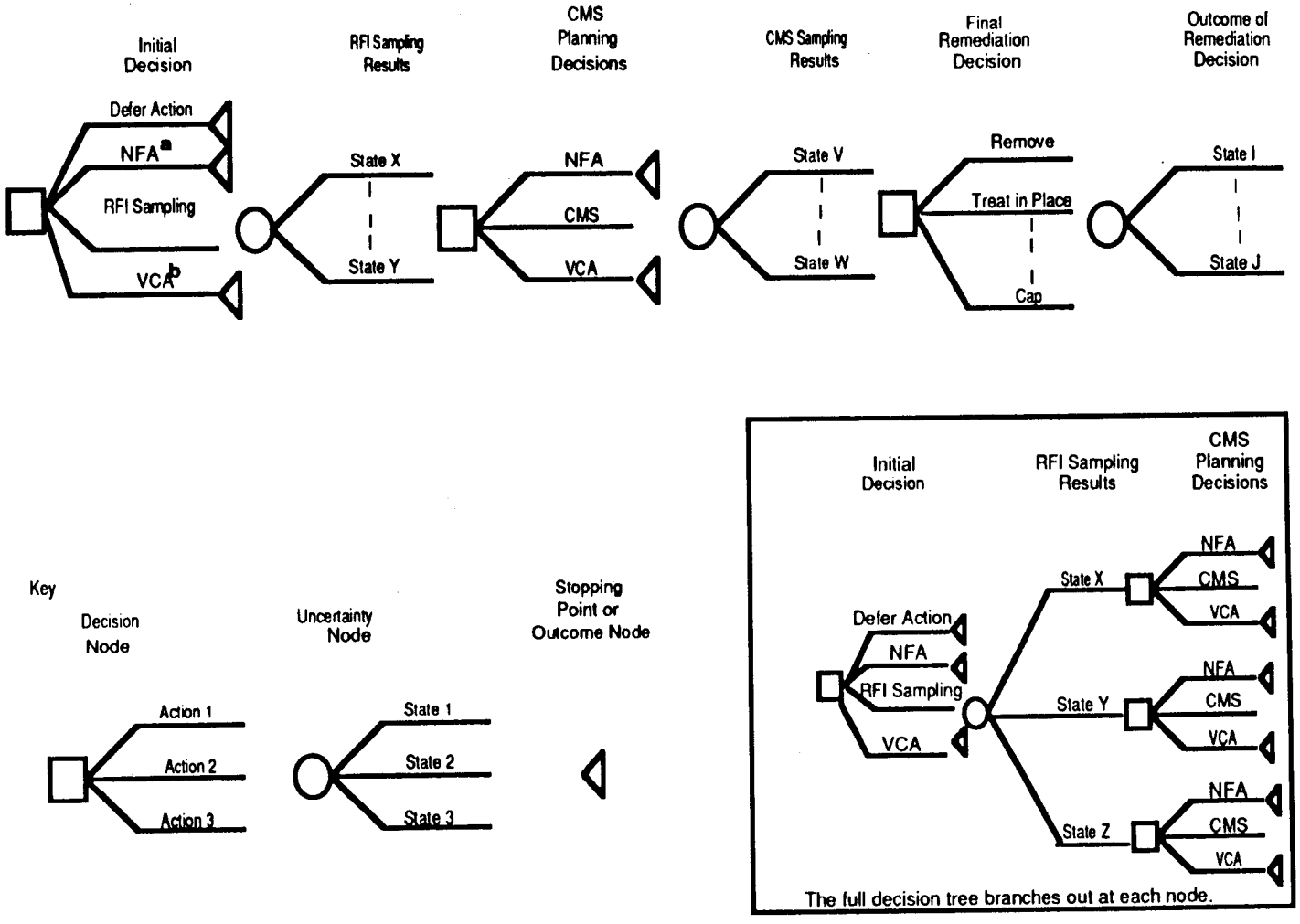
3.4 Application of Decision Analysis in the ER Program

This section describes a decision analysis model that could be used by the ER Program.

Figure I-4 shows a simplified decision tree that corresponds to the RCRA corrective action strategies process diagram shown in Figure I-1. Each branch of a decision node represents one alternative open to the decision maker. Each branch of an uncertainty node represents one possible state of the uncertainty described by that node and is associated with the probability of that state. Thus, uncertainty nodes are described in this tree by discrete probability distributions. Each outcome node describes a final outcome and is associated with the value of that outcome. The full diagram for a decision tree branches out to the right, as illustrated in the inset. Each branch that does not end in an outcome node is connected either to a decision node or to an uncertainty node, together with all of its branches. A path through the tree represents one unique set of decision alternatives and uncertainty states.

Figure I-4 greatly simplifies the RCRA decision process. As described in Section 3.2, there can be many RFI, CMS, and CMI alternatives. Figure I-4 lists only one or a few of each. Likewise, to fully represent the uncertainties during the RFI, CMS, and CMI, a number of uncertainty nodes, each with numerous branches, would be needed. Finally, Figure I-4 presents only one phase each of RFI, CMS and CMI sampling, when, in practice, each may have several phases.

To implement the decision analysis process, the decision maker defines alternatives for each branch of the decision nodes, determines the probabilities associated with each branch of the uncertainty nodes, and assigns values to each final outcome node. Then the investigator can compute an expected value for each path through the decision tree by multiplying probabilities and values, selecting at each decision the alternative on the path that has the highest expected value. (This process is called "rolling back the tree," and decision analysis software packages exist that perform these calculations.) At the end of this calculation, the initial alternative with the highest expected value can be distinguished.



a. No further action.
b. voluntary correction action.

Figure I-4. General decision tree in summary form.

3.4.1 Decisions at the Initial Decision Node

At the first decision node of the tree, the decision alternatives are NFA, deferred action, RFI sampling, or VCA. The decision is based on the likelihood of contamination as estimated from archival information, programmatic guidance, and personal assessment. Because at this stage there is usually little or no quantitative information about the site, RFI sampling is the most common decision.

Sampling alternatives for RFI are described in Section 3.2. Often at this stage, the key future decision for the PRS is whether remediation is required at all, and the key uncertainty is whether contamination is significant. In these cases, Phase I sampling is likely to focus on the presence or average concentration of contaminants in the PRS. Guided by the DQO process, a cost-effective sampling and analysis plan is designed to provide data to confirm or reject, within acceptable levels of error, the hypothesis that contamination exists above a level of concern at the site.

At sites where archival information indicates higher probability that significant contamination is present, the decision on whether remediation is required may depend on the results of a baseline risk assessment. In these cases, Phase I investigations are designed to refine the conceptual exposure model on which this baseline risk assessment is based.

3.4.2 Decisions During Phase I and Phase II Investigations

Sometimes RFIs are conducted in multiple phases. At the initiation of each phase, the decision maker must consider the action alternatives (NFA and VCA) and the alternatives for further investigation (site characterization, risk assessment, or CMS). If characterization is chosen, the decision maker must address the alternatives for sampling. After each phase of characterization, the probability distributions are updated before reconsidering these decisions.

As shown in Figure I-1, if the results of Phase I sampling suggest the presence of constituents at levels of possible concern but provide little specific information, additional sampling to support a baseline risk assessment may be recommended. This follow-up sampling generally focuses on determining the extent of contamination near the PRS and on identifying potential pathways for public exposure. If the Phase I sampling results suggest low levels of constituent concentrations or no credible pathways, a decision for NFA is likely. If the initial results suggest a potential health or environmental hazard and provide enough detail about the extent of existing contaminants, a decision to proceed with a VCA will be taken if an effective remediation alternative is obvious; otherwise, a decision to proceed with a CMS will be taken.

Once knowledge of the site is sufficient to support baseline risk assessment, the major decisions on NFA, VCA, CMS, or continued characterization still remain. If neither NFA nor VCA is chosen at this stage, it is likely that the site will proceed through CMS and CMI. The major future decisions will be on the alternatives for corrective actions, and, therefore, further characterization, if required, will focus on the uncertainties that affect the costs and benefits of remediation alternatives.

As more quantitative information becomes available, more formal application of decision analysis also becomes possible. For example, the decision between NFA

and further action can be evaluated in two ways. First, it can be determined whether NFA meets EPA requirements at an acceptable level of uncertainty or if further action is required. (If further action is required, it can be determined whether VCA or a formal CMS to evaluate alternatives has the lowest expected cost to meet EPA requirements.) Alternatively, however, it can be determined whether NFA or further action is the best course of action based on maximization of the total value, which includes factors in addition to the value placed on compliance. In this latter mode of analysis, instances may be identified in which further action that remediates the site beyond EPA requirements still has positive value. (This approach is similar to the as low as reasonably achievable approach to remediation.) This second form of analysis may also indicate instances in which further action and eventual cleanup to meet EPA requirements have negative total benefits, a result that could occur because of expected environmental impacts of feasible corrective measures, risks to cleanup workers, social disruption, direct dollar costs, or other negative effects of remediation. In these cases, the ER Program may wish to impose conditional remedies (Section 4.5.3).

3.4.3 Decisions Regarding CMS and CMI

Decision alternatives for CMS and CMI are described in Section 3.2. The CMS may include several phases: feasibility studies, bench or pilot tests of corrective studies, and final engineering studies. Selection of a corrective action for implementation is based on the probabilities and values associated with the long-term outcomes.

During the CMI, new information about the effectiveness of corrective actions and site conditions may be obtained. This information may result in decisions to alter the engineering design of the corrective action.

The final uncertainty node is the outcome of the implemented corrective action. This one uncertainty node is a representation of all of the individual residual uncertainties that exist at a site and how they will affect workers and the public in the future. This true state of the site will only be revealed over time. The final decision on corrective action must be made with recognition of these unresolvable uncertainties.

4.0 EXAMPLE APPLICATIONS OF DECISION ANALYSIS

This section steps through two applications of decision analysis in the ER Program.

4.1 Proposed No Further Action and Deferred Action after Archival and Field Reconnaissance Investigations

In the first stages of investigating a site, little quantitative information may be available. In this case, an NFA or a deferred action decision, if taken, must be based on a subjective evaluation of the site. The NFA or deferred action criteria described below can be used to guide this subjective evaluation. The criteria illustrate the use of scales to support such evaluations, but, in this case, only one level of each scale is described—specifically, the most favorable or lowest-risk level. Thus, at this early stage, the recommendation for NFA is only made if the PRS meets the strictest standards.

According to proposed Subpart S to 40 CFR 264 (EPA 1990, 0432), a PRS can be recommended for NFA if it can be demonstrated that the PRS poses no threat to

human health or the environment. This section describes a four-step procedure for determining, based on archival information, whether a PRS meets this requirement or meets other conditions that would allow the PRS to be recommended for NFA or a delay in characterization. This process is illustrated in Figure I-5.

Step 1: In the first step, the OUPL ensures the accuracy of the PRS data base maintained by the ER Program's Facility for Information Management and Display (FIMAD). Specifically, he/she checks the following:

- The PRS has not been closed.
- The PRS is correctly numbered.
- The PRS is correctly located.
- The PRS data base is otherwise accurate.

If the PRS data base is not correct, the OUPL needs to provide up-to-date information to the FIMAD. If in correcting the data base it is determined that the PRS is already properly closed or never existed, the PRS should be recommended for NFA and delisting. Otherwise, the evaluation moves to the second step based on the corrected data base.

Step 2: In the second step, the OUPL determines whether the site should be addressed by another program and excluded from the ER Program. Any of the following conditions could exclude a PRS from the ER Program and lead to a recommendation for NFA and delisting from the HSWA Module.

- The PRS began operation after November 1988. The ER Program will evaluate each site and determine, on a case-by-case basis, whether it falls under the ER Program.
- The PRS involves a discharge to surface waters and has always operated under a Part B, National Pollution Discharge Elimination System permit or began operation after 1972.
- The PRS is a satellite that has been used as a storage area for less than 90 days and that is not a historical release site.

Step 3: At PRSs that are not recommended for NFA, characterization may be delayed beyond the current RFI if any of the following pertains to the site:

- The PRS is operating under a RCRA permit [RCRA Section 3004 (a)] or interim status.
- The PRS is an active site from which no credible pathways lead off the site.
- The PRS is an inactive site that cannot be characterized or remediated without disrupting activities at an active site and from which no credible contaminant pathways lead off the site.

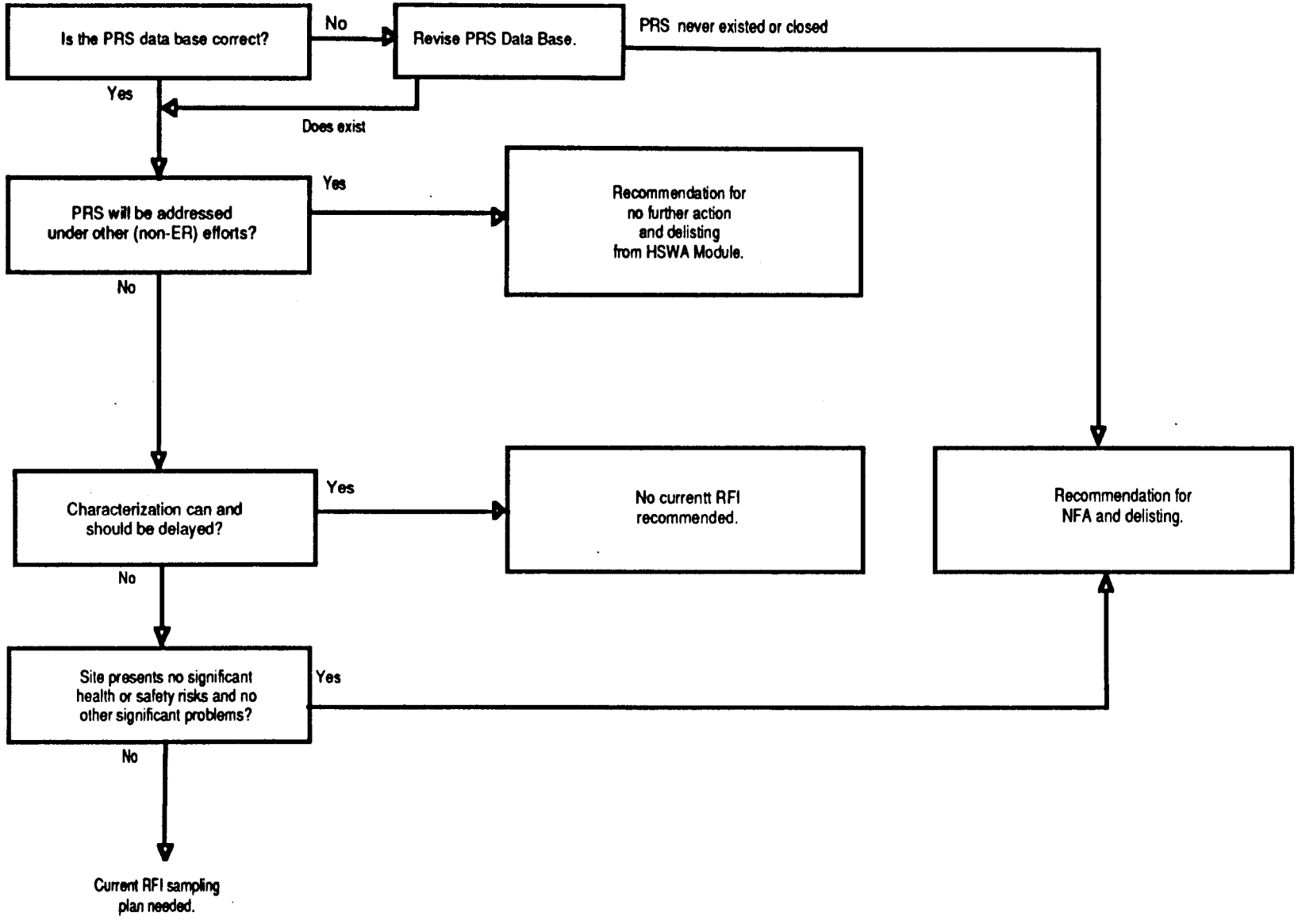


Figure I-5. Decisions for delayed investigation.

- VCA or institutional control is already planned for the PRS. In the latter case, no credible pathways lead from the PRS off the site.

In cases of active sites, inactive sites associated with active sites, and sites for which institutional control is planned, characterization takes place in conjunction with future remediation. This remediation will be coordinated with decontamination and decommissioning. In the case where VCA is planned, characterization takes place in conjunction with the VCA. For all other scenarios, the process proceeds to a detailed review of health, safety, and other problems at the PRS.

Step 4: This last step is to review health, safety, and other problems. In this step, the remediation needs of the PRS are examined with respect to several factors. If any of the conditions of this review are not met, the site is not recommended for NFA and needs a current RFI sampling plan. The review is summarized in Figure I-6 and includes a review of the following:

- health and safety risks, based on archival information, which are assessed for
  - site workers (who are performing routine site operations rather than characterization and remediation activities) to determine that potential risk agent(s) are far enough below screening action levels (SALs) or that the lack of credible exposure scenarios ensures that they pose no danger to site workers for any foreseeable activity (excavation, removing or moving fill, drilling, etc.).
  - offsite workers to determine that the potential risk agent(s) have not migrated to new locations or evolved into new forms in such a way that they are near SALs or in any way pose a danger to offsite workers for any foreseeable activity.
  - onsite and offsite members of the public to determine that the potential risk agent(s), together with containment and local use patterns, do not now nor will they in the foreseeable future pose a danger to the public either on or off the site.
- risk to the environment
  - The nature and current status of the constituents and environmental pathways preclude impact on environmental resources, including those resources listed in Table I-1.
  - The nature and current status of the constituents and environmental pathways are such that the likely scenarios for exposing sensitive environmental resources will not result in any damage.

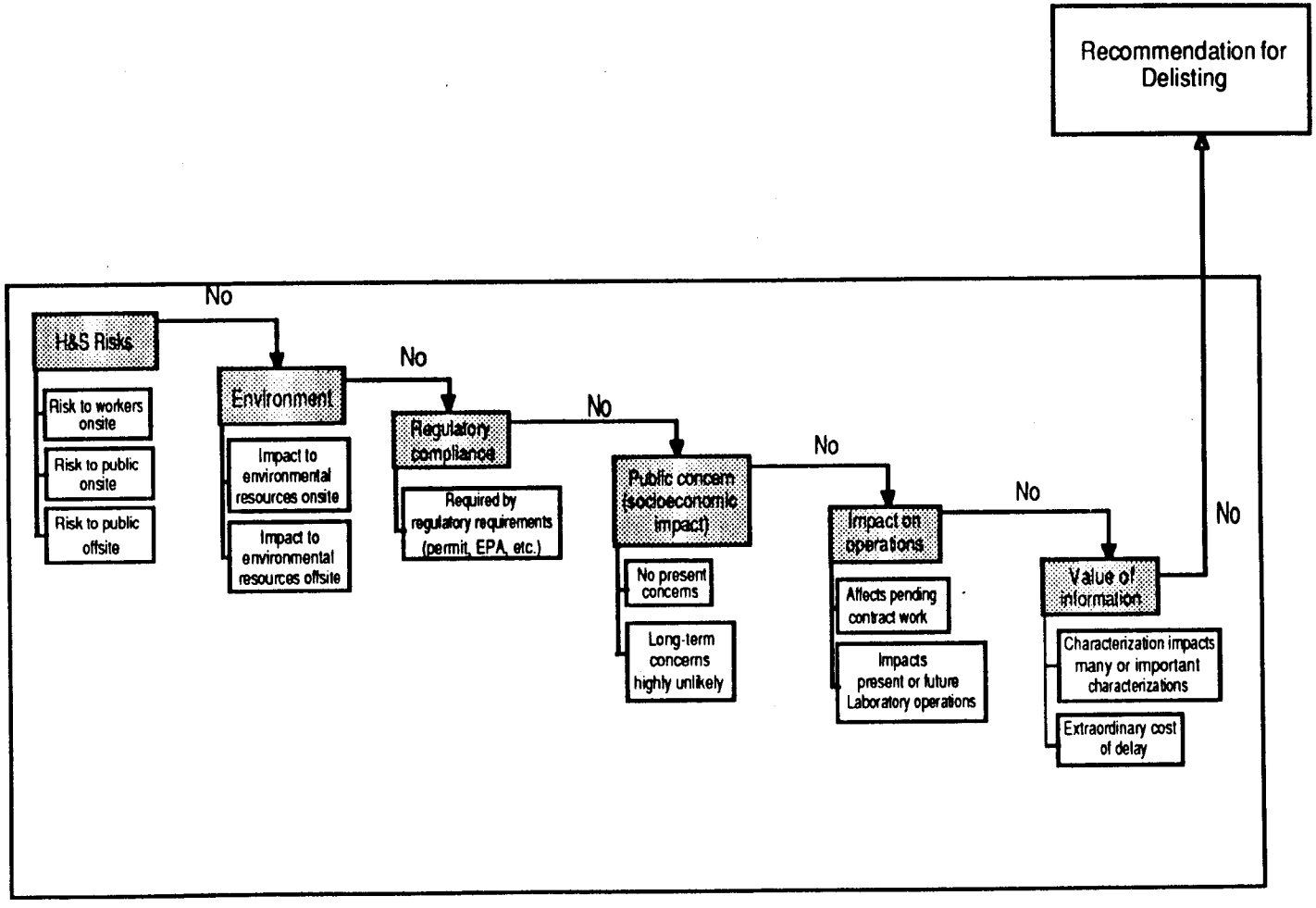


Figure I-6. Review for health, safety, and other problems.

TABLE I-1

ENVIRONMENTAL RESOURCES IN THE LOS ALAMOS AREA

Federally endangered species	Concern for habitat of peregrine falcon and bald eagle
State endangered species	Jemez Mountain salamander Gramma grass cactus Wood lily
Candidate for the federal register	Northern goshawk
Federally protected resources	Wetlands; habitat supporting threatened and endangered species
Other resources	State-designated natural areas, wildlife management areas, scenic areas, to protect unique biotic communities
	Federal wild and scenic river (Jemez River)
	Federal wilderness area (Bandelier National Monument)
	National Park and National Forest (Bandelier National Monument and Santa Fe National Forest)

- regulatory compliance

  applicable regulatory requirements do not require characterization because of the contaminant(s), the location, the migration pathways, or other factors.

- public concern

  workers and area residents have no immediate or long-term concerns about or interest in the characterization of the PRS.

- impact on Laboratory programs and operations

  - Failure to characterize the PRS poses no immediate threat or long-term danger of causing an adverse impact on Laboratory programs, such as temporarily shutting down a Laboratory facility, reducing the size or number of existing programs, or influencing future programs.

  - There is no danger that failure to characterize the PRS will cause an adverse impact on a Laboratory operations (such as contamination of or other harm

to critical equipment or that drainage will contaminate other operations).

- There will be no regulatory curtailment of other operations or programs because of failure to characterize this PRS.

- value of Information

Characterization of the PRS does not contribute to the effectiveness or value, nor does it reduce the expense of other characterizations, and, if not done, will not result in extraordinary costs, risks, or socioeconomic impacts should characterization be required at a later date.

There is no reasonable basis for characterizing the PRS if the site satisfies all the conditions described above. Thus, the PRS is recommended for NFA and delisting.

4.2 Case Study Showing Application of Decision Analysis

This case study is intended to illustrate how decision analysis can be applied to planning and implementing characterization and remediation of material disposal areas and landfills at the Laboratory.

4.2.1 Landfill Description

The hypothetical industrial landfill examined in this case example was identified as a possible remediation site during the RCRA field assessment. The landfill was used mainly for disposing of residues resulting from burning materials contaminated with high explosives but also contains construction debris such as large pieces of timber, concrete rubble, and pipes. In addition, it contains miscellaneous, nonconstruction debris, such as flasks, bottles, and other items used in manufacturing and testing high explosives (HE). The landfill contains an estimated 13,000 yd^3 of waste.

The landfill, which is located in a saddle of a short mesa and occupies approximately 2 acres, extends down the slope of the canyon to form a shelf over the original slope of the canyon. Although the landfill does not reach the canyon bottom, a few large items have fallen to the bottom. An intermittent stream runs through the canyon below and eventually into the Rio Grande. Past testing has shown that barium is present in the landfill over EP toxic levels. Other contaminants of concern are unburnt HE.

The potential mechanisms by which existing contamination could cause onsite exposure or lead to transport off the site are leaching to the tuff below and eventually into the groundwater, storm water run-off, mass wasting, erosion, and excavation of the landfill for remediation purposes.

4.2.2 Formulating Decision Analysis

A decision analysis team was formed to review background material on the landfill. The team interviewed experts to formulate the problem, using an influence diagram to depict the decisions, uncertainties, and values in the problem and the relationships

between them. The formulation was further revised through additional consultation with experts.

A two-stage analysis was performed for this problem. First, the team determined the remediation approach that would be taken if the approach had to be chosen immediately. Second, the team examined possible characterization activities to determine what activities have the potential to improve this preliminary decision at reasonable cost.

A simple influence diagram for this problem is shown in Figure I-7. In this diagram, the rectangle contains the decision about the remediation alternatives. Ovals indicate uncertainties, including all of the uncertain current conditions of the landfill, such as the type and amount of contamination, the stability of the slope, the extent and pathways of migration, and the uncertainties regarding costs such as the costs of material disposal and the costs of safety precautions. The values noted in the rounded rectangle are the same as those adopted for the ER Program as a whole. Finally, arrows indicate influences; an arrow from an uncertainty to a value indicates that the value depends on the state of the uncertainty.

The analysis team identified the feasible corrective action alternatives available for the landfill. The alternatives considered were (1) full removal and (2) treating in place, capping, and monitoring.

In the second alternative, the barium in the landfill is treated by mixing it with sodium sulfate to form barium sulfate. Then a cap is placed over the landfill and a monitoring system is set up to measure potential offsite migration of contaminants. The uncertainties at the site include

- quantity of contamination in the landfill,
- toxicity of the contaminants,
- pathways of migration to the tuff and offsite and the extent to which migration has occurred,

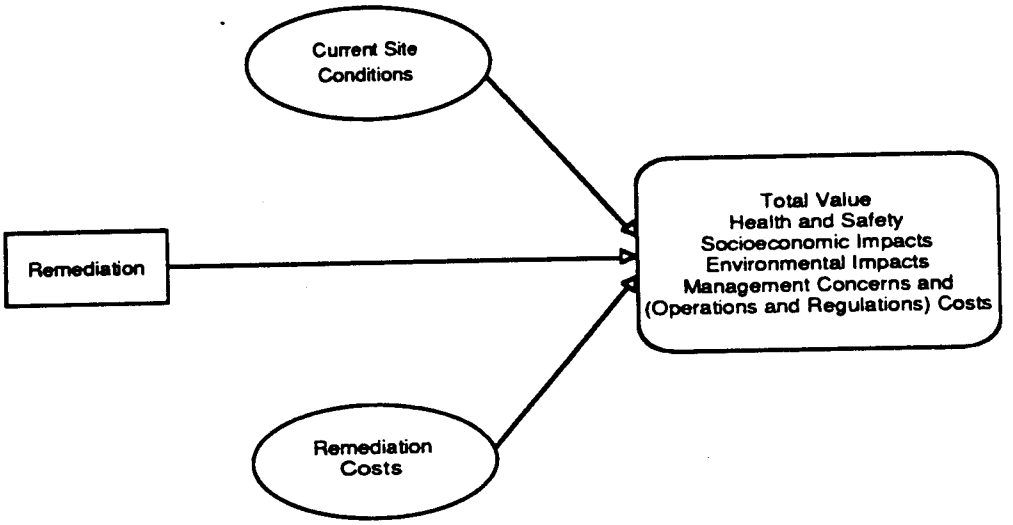


Figure I-7. High-level influence diagram.

- stability of the slope,
- impact of HE as the result of an explosion during remediation,
- environmental impacts of contamination,
- environmental impact of the remediation alternatives,
- extent of exposure of the public to contaminants,
- extent of exposure of workers to contaminants, and
- costs of remediation.

As the analysis proceeded and more information was gathered, some of these uncertainties became known quantities, and others were found to be irrelevant.

The initial list of values used by the analysis team are the ER Program values: health and safety, socioeconomic impacts, environmental impacts, Laboratory operations, and costs. Health and safety concerns include the health and safety of both the public and workers. Potential impacts on workers include exposure through remediation and the impacts of HE explosions. Socioeconomic impacts result from public concern and impacts on the local economy. Environmental impacts include impacts on flora and fauna on and off the site. Laboratory operations are of concern because they could be disrupted by remediation. In addition, regulatory issues are of concern because of their effect on Laboratory operations. The final value, costs, includes the costs of characterization and remediation. It was assumed that the cost of disposal at an approved site would cover all future costs of management.

4.2.3 Deterministic Analysis

A deterministic model is constructed to calculate a measure of total value for each alternative. A graphical representation of the structural model used in this analysis is shown in Figure I-8.

In a typical decision analysis, in order to calculate the total value, a measurement scale for each final outcome is developed. Then each final outcome is scored on its own scale, and the scores are aggregated in a total value through a multiattribute utility function. However, in this simplified analysis, the only value taken into account in the model is costs. It is assumed that each of the remediation alternatives is adequate to remove all health and safety concerns and has only minor, if any, impacts on the environment. Moreover, it has been determined that neither of the alternatives would impact Laboratory operations and that both would be approved by EPA and state regulators. Neither alternative is seen as having significant socioeconomic impacts. Therefore, costs become the only criterion against which the outcomes need to be evaluated.

The structural model shown in Figure I-8 calculates the costs of each alternative. Arrows indicate the inputs that are needed to calculate each value in the diagram. Three aspects of the model should be noted. First, it is assumed that if removal is chosen, not all disposal area materials will be classified as hazardous wastes. Only the fraction of the materials that is contaminated will be disposed in a hazardous waste landfill. Uncontaminated materials will be disposed at much lower cost in a standard landfill. Second, it is assumed that the expenditure for worker safety will

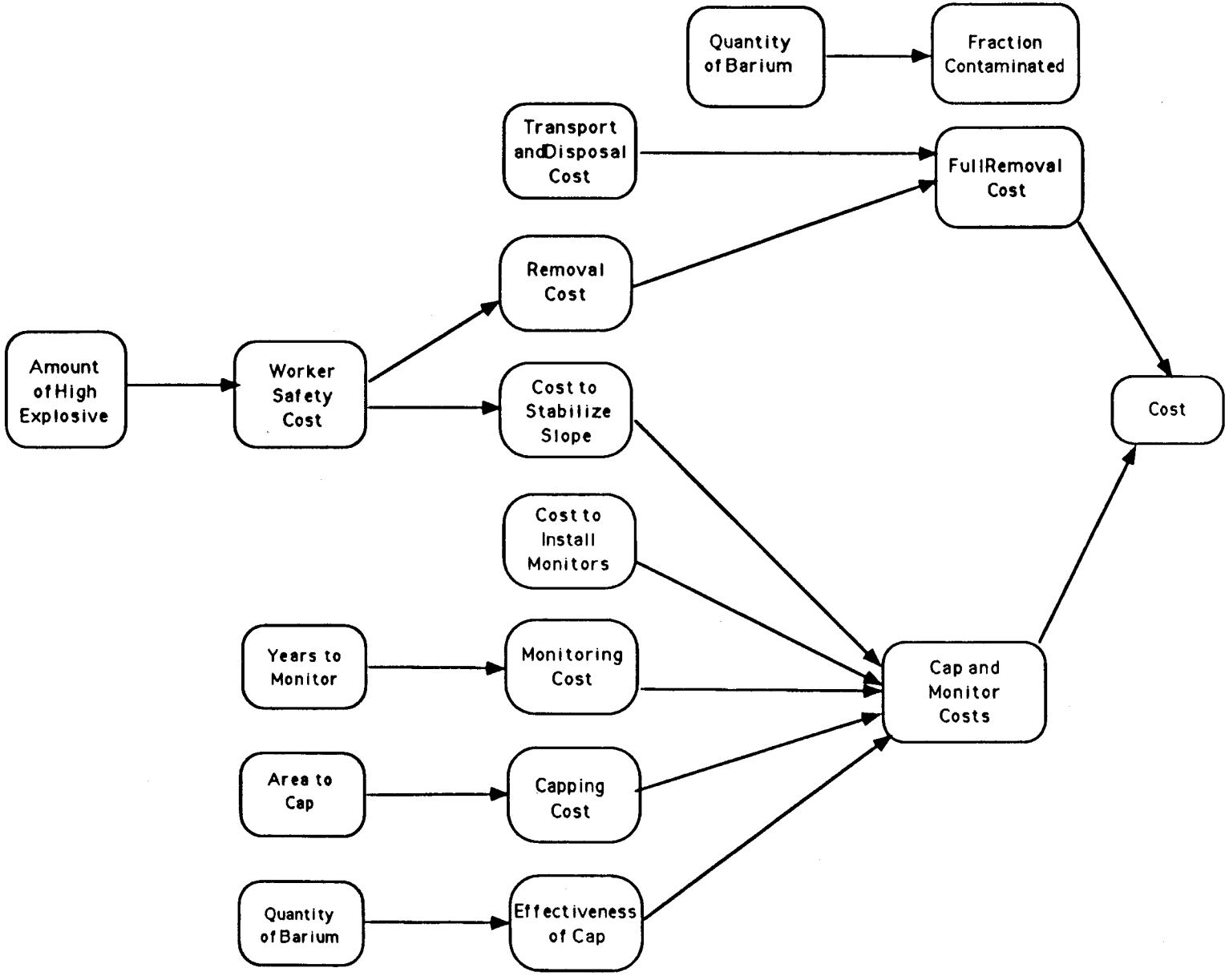


Figure I-8. Structural model.

be determined by the level of unburnt HE in the landfill, and it is assumed that the impact of safety costs will be much higher for removing the HE and stabilizing the slope than for capping. Third, it is assumed that if the cap proves ineffective at the end of 5 years, the material in the landfill will be removed and the cost of removal will be incurred at that time.

The investigators use this model to find a nominal solution and to perform a sensitivity analysis to identify important uncertainties. Table I-2 lists the nominal states of the uncertainties and the worst and best extremes. The nominal analysis suggests that the capping and monitoring option is the preferred solution. The discounted total costs for capping and monitoring are $2.3 million and for removal are $3.4 million.

The sensitivity analysis indicates that the decision to remove or to cap and monitor is not sensitive to two uncertainties: the cost of stabilizing the slope and the quantity of HE. The range of slope stabilization costs is too small compared with other costs to have much impact on the final solution. The HE-related safety costs for each alternative are too similar to have much impact. Therefore, these uncertainties are set at their nominal state in the model.

The outcomes are deemed to be sensitive to the other three uncertainties. If the fraction of the disposal area contaminated is very low, disposal costs are cut dramatically, and full removal becomes a better solution than capping and monitoring. If the cap is ineffective, removal is superior to capping now and still incurring removal costs in the future. Finally, although the standard sensitivity analysis shows that the quantity of barium does not affect the decision, it is decided to continue to treat the quantity of barium as an uncertainty because there is concern that the impacts of the quantity of barium on the two important uncertainties, fraction contaminated and effectiveness of capping, are not adequately captured in the sensitivity analysis.

4.2.4 Probabilistic Analysis

The next step in the decision analysis cycle is to construct the probabilistic model of the problem (Figure I-9). From left to right, the decisions and uncertainties in the model are the corrective action decision, quantity of barium, fraction of the disposal area contaminated, and effectiveness of the cap; the structure of the tree is identical for the removal branch. The probabilities and states of uncertainties used in this model are gathered from experts designated by the OUPL. Because the sensitivity analysis indicates that the corrective action decision is not sensitive to two uncertain-

TABLE I-2

VALUES FOR NOMINAL-CASE AND SENSITIVITY ANALYSIS

Uncertainty	Worst	Nominal	Best
Quantity of barium	High	Nominal	Low
Fraction of volume contaminated (%)	65	55	15
Cost to stabilize slope	$1,000,000	$750,000	$500,000
Quantity of HE (worker safety multiplier)	5	1	—
Effectiveness of capping	Ineffective	Effective	Effective

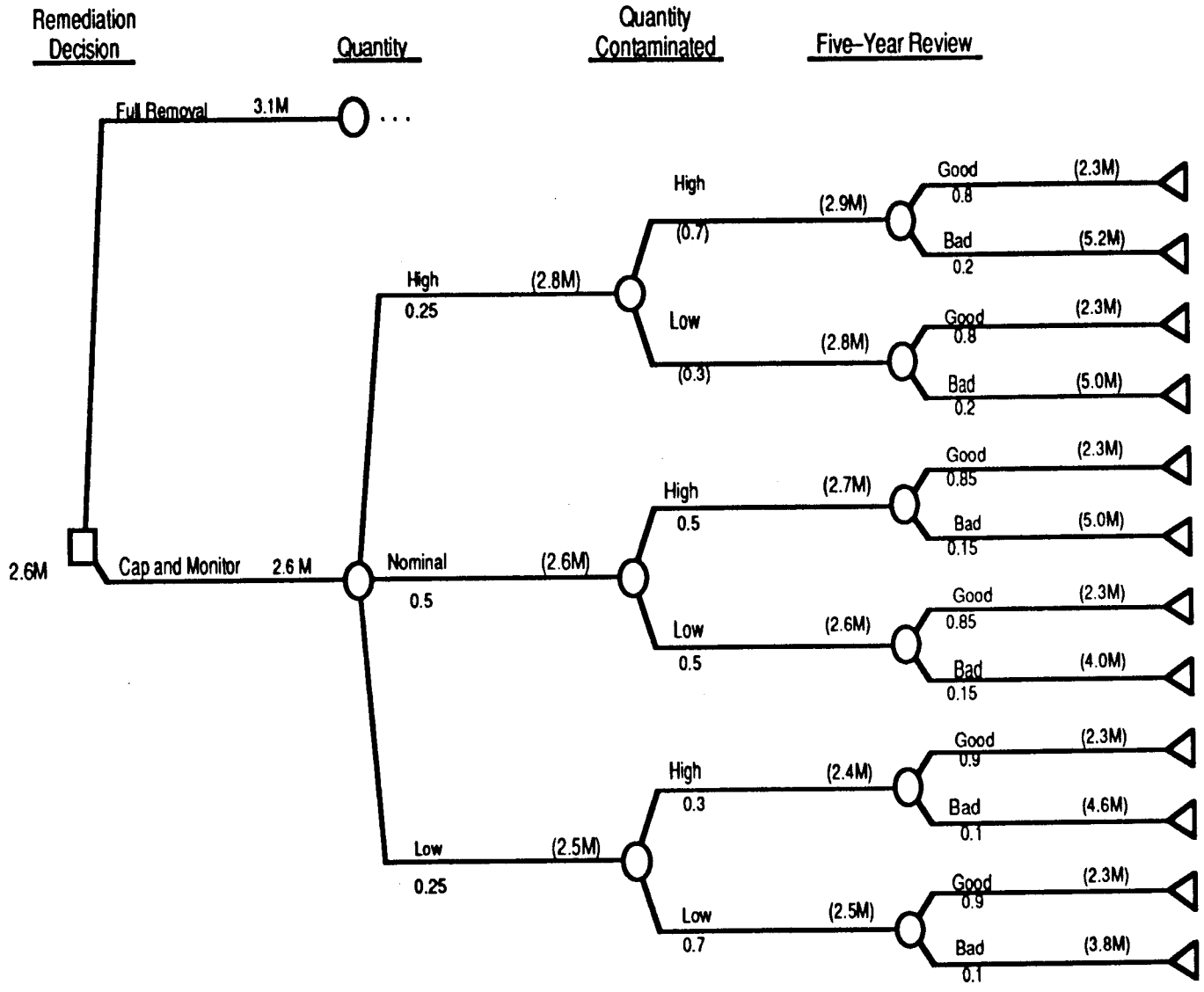


Figure I-9. Decision tree for corrective action.

ties and that these uncertainties can be set at their nominal states, the need for data collection in this step is minimized.

4.2.5 Evaluation: Determining the Optimal Decision and Value of Information

If it were necessary to make the decision immediately, the decision analysis would point to capping and monitoring as the least costly alternative; however, this alternative does pose somewhat higher extreme risks. The expected cost of the capping and monitoring alternative is $2.63 million, and the expected cost of the removal alternative is $3.13 million. These results are illustrated in Figure I-10, which shows the cumulative distributions on costs for both alternatives. The cumulative distribution indicates the probability that the actual cost will be lower than a value chosen on the horizontal access. Although the capping and monitoring alternative has lower expected costs, removal has a higher probability of avoiding very high costs because of the small chance that the cap may prove ineffective. For removal, it is almost certain that costs will be less than $4.5 million, but, for capping and monitoring, the probability that costs are less than $4.5 million is only 0.9.

At this time in the RCRA process, decisions regarding site characterization are perhaps more important than decisions on the final method of remediation. In a second stage of the decision analysis, characterization decisions can be analyzed with a minor expansion of the model. Characterization alternatives that might be considered are

- develop more detailed costs estimates,
- drill deep holes to accurately determine the quantity of barium and the fraction of the disposal area contaminated, and
- take less accurate, shallow samples to determine the quantity of barium and the fraction of the disposal area contaminated.

The first consideration is the value of obtaining perfect information on the quantity of barium and fraction contaminated. The value of perfect information provides an upper bound on how much to spend on characterization activities to resolve these uncertainties. The expanded decision tree for the analysis of the value of perfect information is shown in Figure I-11. The difference between this expanded tree and the tree shown in Figure I-9 is that two uncertainty nodes have been moved before the corrective action decision node, indicating that these two uncertainties are known at the time of the decision.

The analysis shows that the value of perfect information is approximately $70,000. Because the minimum cost of digging deep holes for taking samples in the disposal area is higher than this value, this characterization activity was not considered further. A program using less accurate, shallow samples is estimated to cost $50,000. However, the expected value of the additional information gained is only $35,000. Therefore, neither of these characterization activities can be recommended. The decision analysis indicated that either new characterization activities be formulated or that the capping and monitoring strategy be adopted without further characterization.

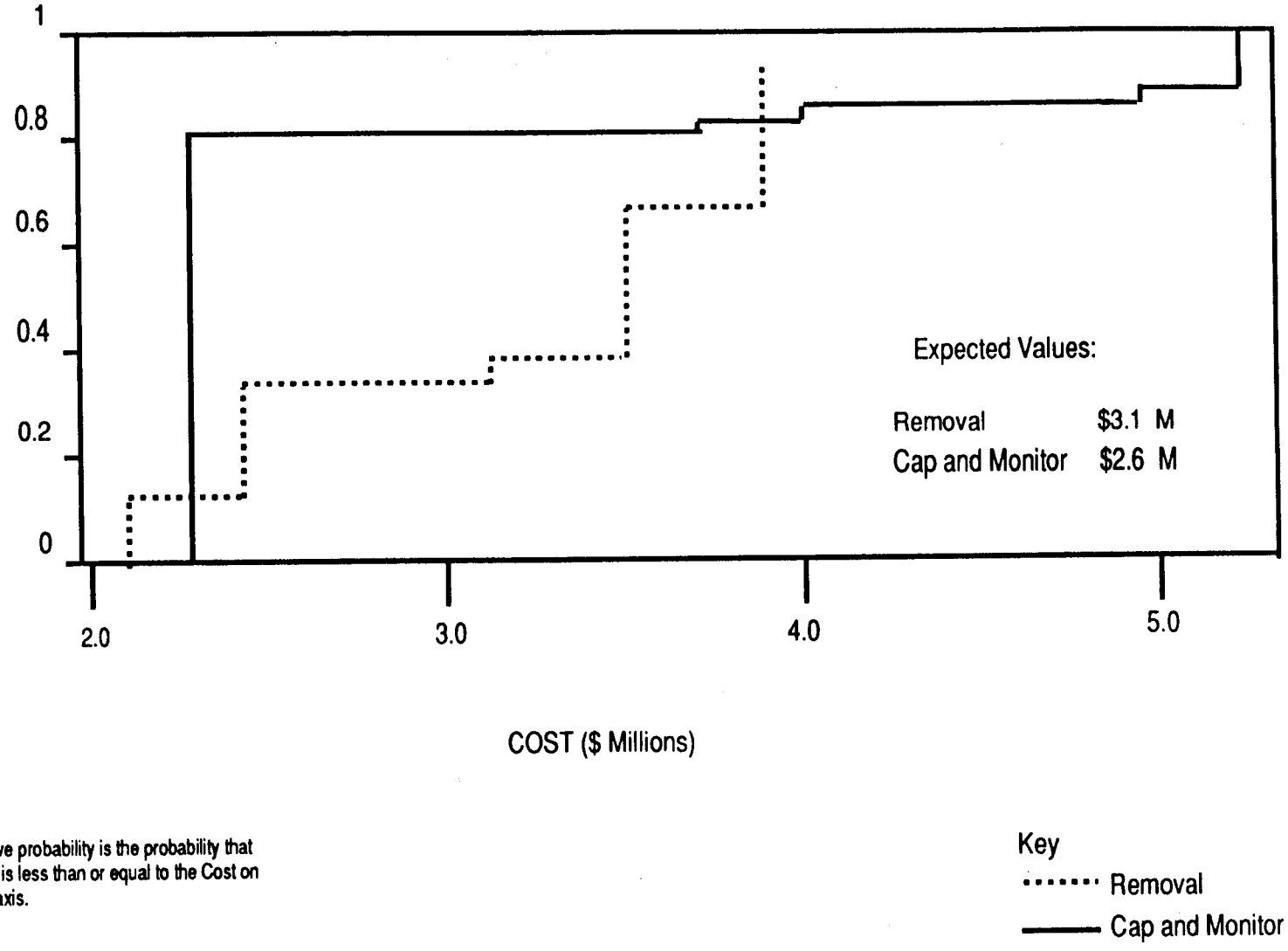


Figure I-10. Results of corrective action analysis.

* The cumulative probability is the probability that the actual cost is less than or equal to the Cost on the horizontal axis.

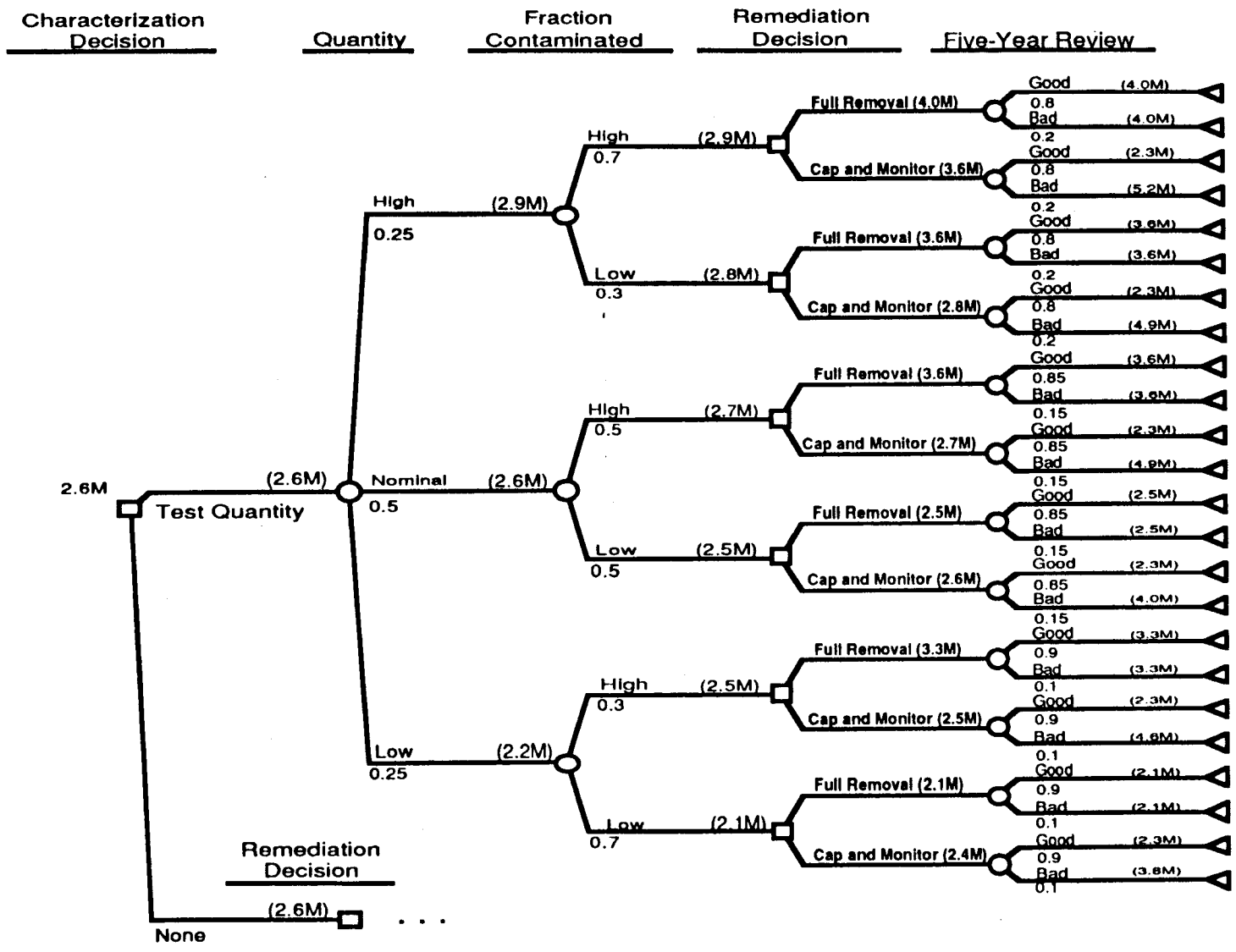


Figure I-11. Decision tree for perfect information.

This example illustrates the application of decision analysis to both characterization and remediation problems. It shows how decision analysis can provide a valuable tool for intelligently using the full range of expertise and data available at the Laboratory to make decisions throughout the RCRA process.

References for Appendix I

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■ APPENDIX J

Derivation of Screening Action Levels

1.0 SCREENING ACTION LEVELS FOR NONRADIOLOGICAL CONSTITUENTS

Proposed Subpart S to the Resource Conservation and Recovery Act (RCRA) (EPA 1990, 0432) presents a methodology for calculating action levels to be used for various environmental media (i.e., groundwater, surface water, air, and soil). The action levels are calculated using chemical-specific toxicity values and default exposure parameters. In order to comply with the Hazardous and Solid Waste Amendments (HSWA) Module for (Los Alamos National Laboratory (the Laboratory), screening action levels (SALs) have been developed that follow the Subpart S methodology but that incorporate more recent toxicity values available from the Environmental Protection Agency's (EPA's) Integrated Risk Information System (IRIS) data base (EPA 1992, 0830) and Health Effects Assessment Summary Tables (HEAST) (EPA 1992, 0833).

A plan for evaluating data is needed before any data are collected in order to ensure that the data will be adequate for comparison with SALs and for possible subsequent risk assessment. For example, detection limits need to be lower than SALs to permit adequate comparisons. Details of appropriate data evaluation steps, both before and after data are obtained, are to be provided in Appendix K (Baseline Risk Assessment Methodology).

In Sections 1.1 and 1.2, the assumptions and equations for calculating SALs for soil, groundwater, surface water, and air are presented. Section 1.3 discusses the evaluation of multiple constituents present in a single environmental medium. Section 1.4 addresses the derivation of SALs for other media or substances that may be present in various operable units at the Laboratory.

1.1 Assumptions

The SAL values presented in Table J-1* are based on the methodology presented under proposed Subpart S (EPA 1990, 0432) and on toxicity values (i.e., reference doses and carcinogenic slope factors) from the IRIS data base (EPA 1992, 0830) or the HEAST (EPA 1992, 0833). The constituents included in Table J-1 are those of the EPA's Target Analyte List (EPA 1991, 0778) and Target Compound List (EPA 1991, 0779), excluding pesticides and polychlorinated biphenyl compounds. Uranium has also been added to the list because it may have significant chemical toxicity in addition to effects associated with its radiological activity. Other constituents may need to be added as the results of site characterization become available. SALs presented in Table J-1 will be updated on an annual basis to reflect any modified toxicity values.

The SALs are based on the following assumptions and equations contained in proposed Subpart S:

1. In deriving soil SALs that consider systemic (i.e., noncarcinogenic) effects, a child's daily intake is modeled. A soil ingestion rate of 200 mg/day by a 16-kg child is assumed. Intake is assumed to occur 365 days/yr.

*The tables in this appendix follow the text.

For carcinogenic constituents in soil, the long-term exposure of an adult is modeled. A soil ingestion rate of 100 mg/day by a 70-kg adult is assumed. Intake is assumed to occur 365 days/yr over a 70-yr exposure period.

2. A modification to the above methodology has been introduced for volatile constituents in soil. The modification is needed to account for potential exposure via inhalation and is incorporated in more recent EPA guidance for the calculation of preliminary remediation goals (PRG) (EPA 1991, 0302). Because SALs for volatile substances calculated using this modified approach are lower (i.e., more conservative) than those calculated using the similar Subpart S method, this approach has been selected for use in the Laboratory's Environmental Restoration Program. For the purpose of calculating SALs, volatile constituents are defined as those with molecular weight less than 200 and Henry's Law Constant greater than 1×10^{-5} atm/m^3-mole (EPA 1991, 0302).

   The equation for calculating SALs for volatile constituents has been expanded to account for potential inhalation exposure (equation below). The soil-to-air volatilization factor was calculated based on an equation given by EPA (1991, 0302) and chemical-specific parameters (Strenge and Peterson 1989, 0777; EPA 1988, 0747). The default particulate emission factor was used in SAL calculations for volatile constituents to maintain consistency with the equation given in the PRG guidance document (EPA 1991, 0302), although this factor is so low that it does not impact the calculated SALs. The SAL calculation for volatile constituents with systemic effects models exposure of a 16-kg child with a soil ingestion rate of 200 mg/day and an inhalation rate of 20 m^3/day. The SAL calculation for carcinogenic volatile constituents models exposure of a 70-kg adult over a 70-yr exposure period, with a soil ingestion rate of 100 mg/day and an inhalation rate of 20 m^3/day.

3. In deriving SALs for constituents in water, the daily intake level is assumed to be 2 L/day by a 70-kg adult. Intake is assumed to occur 365 days/yr over a 70-yr exposure period. These SALs apply both to groundwater and to surface water constituents.

4. In deriving SALs for constituents in air, the daily intake level is assumed to be 20 m^3/day by a 70-kg adult. Intake is assumed to occur 365 days/yr over a 70-yr exposure period.

5. Proposed Subpart S specifies the use of maximum contaminant levels (MCLs) promulgated under the Safe Drinking Water Act as action levels for groundwater constituents. Subpart S also indicates that state water quality standards established pursuant to the Clean Water Act, Section 303c and expressed as numerical values will be used as action level criteria for surface water constituents when these standards have been established for the surface water body in question. When numeric water quality standards have not been established by the state, Subpart S specifies that MCLs will be used as action levels, if the surface water has been designated as a drinking water source by the state.

Federal MCLs and state groundwater standards are presented in Table J-2. In keeping with Subpa S instructions, the lowest of (1) the MCL value, (2) the state groundwater standard, or (3) the value calculated using the specified exposure assumptions for water (Number 3 above) will be used as the SAL for chemicals with available MCL and/or state groundwater standards. Although not specifically stated, it is consistent with Subpart S to use the same SAL criteria for both groundwater and surface water constituents. For surface water constituents, these criteria may be more stringent than required because the state has not designated the surface waters to be evaluated as drinking water sources.

1.2 Equations

1.2.1 General Equations for Calculating SALs

1.2.1.1 Systemic Toxicants

$$SAL = \frac{THI \times RfD \times BW \times CF}{I \times A},$$

where

SAL = SAL: mg/kg for soil SALs, µg/L for water SALs, µg/m^3 for air SALs

THI = target hazard index: 1

RfD = chronic reference dose (mg/kg/day): oral RfD used for soil and water SALs, inhalation RfD used for air SALs

BW = body weight: 16 kg for child (for soil SALs), 70 kg for adult (for water and air SALs)

CF = conversion factor: 10^6 mg/kg for soil SALs, 10^3 µg/mg for water and air SALs

I = intake rate: 200 mg/day for soil SALs, 2 L/day for water SALs, 20 m^3/day for air SALs

A = absorption factor: 1.

1.2.1.2 Carcinogenic Constituents

$$SAL = \frac{R \times BW \times LT \times CF}{SF \times I \times A \times ED},$$

where

R = target risk: 10^{-6} for Class A and B carcinogens, 10^{-5} for class C carcinogens

BW = body weight: 70 kg

LT = assumed lifetime: 70 yr

CF = conversion factor: 10^6 mg/kg for soil SALs, 10^3 µg/mg for water and air SALs

SF = slope factor $(mg/kg/day)^{-1}$: oral SF used for soil and water SALs; inhalation SF used for air SAL

I = intake rate: 100 mg/day for soil SALs, 2 L/day for water SALs, 20 m^3/day for air SALs

A = absorption factor: 1

ED = exposure period: 70 yr.

1.2.2 Equations for Calculating Soil SALs for Volatile Constituents

1.2.2.1 Systemic Toxicants

$$SAL = \frac{THI \times BW}{[1/RfD_o \times 10^{-6}\ kg/mg \times ING] + [1/RfD_i \times INH \times [1/VF + 1/PEF]]},$$

where

THI = target hazard Index: 1

BW = body weight: 16 kg

RfD_o = chronic oral reference dose: mg/kg/day

ING = soil ingestion rate: 200 mg/day

RfD_i = chronic inhalation reference dose: mg/kg/day

INH = inhalation rate: 20 m^3/day

VF = soil-to-air volatilization factor (chemical-specific): m^3/kg, calculated using equation given by EPA (1991 0302) and chemical-specific parameters (Strenge and Peterson 1989, 0777; EPA 1988, 0747).

PEF = particulate emission factor: 4.63×10^9 m^3/kg (EPA 1991, 0302).

1.2.2.2 Carcinogenic Constituents

$$SAL = \frac{R \times BW \times LT}{ED \times [[SF_o \times 10^{-6}\ kg/mg \times ING] + [SF_i \times INH \times [1/VF + 1/PEF]]]},$$

where

R = target risk: 10^{-6} for Class A and B carcinogens, 10^{-5} for Class C carcinogens

BW = body weight: 70 kg

LT = assumed lifetime: 70 yr

ED = exposure period: 70 yr

SF_o = oral slope factor $(mg/kg/day)^{-1}$

ING = soil ingestion rate: 100 mg/day

SF_i = inhalation slope factor $(mg/kg/day)^{-1}$

INH = inhalation rate: 20 m^3/day

VF and PEF as defined above.

1.3 Addressing Multiple Constituents

Proposed Subpart S does not address the evaluation of several constituents in a single environmental medium. To address this potential concern, a simple method presented in guidance for CERCLA investigations (EPA 1989, 0305) will be used.

For systemic toxicants, the exposure assumptions given in Section 1.2 will be used to calculate a constituent exposure level as follows:

$$E_i = \frac{C_i \times I}{BW \times CF} ,$$

where

E_i = exposure level for i^{th} constituent (mg/kg/day)

C_i = concentration of ith constituent in environmental medium; mg/kg for evaluation of multiple constituents in soil; µg/L for evaluation of multiple constituents in water; and µg/m^3 for evaluation of multiple constituents in air

I = intake rate: 200 mg/day for evaluation of systemic toxicants in soil, 100 mg/day for evaluation of carcinogens in soil, 2 L/day for evaluation of multiple constituents in soil, 20 m^3/day for evaluation of multiple constituents in air

BW = body weight: 16 kg for evaluation of systemic toxicants in soil; 70 kg for all other evaluations.

CF = conversion factor: 10^6 mg/kg for soil evaluations, 10^3 µg/mg for water and air evaluations.

The exposure levels for all constituents with systemic effects present in a given environmental medium will be divided by the chemical-specific reference dose (either oral or inhalation, depending on the medium being evaluated) to obtain the "hazard quotient" and will be summed to create the "hazard index," using the following equation:

$$\hat{A}_{1}^{i}(E_i/RfD_i) ,$$

where

E_i = exposure level for the ith constituent

RfD_i = reference dose for the ith constituent.

This medium-specific hazard index will be compared with an acceptable hazard index level of 1. In instances where the hazard quotient for an individual constituent is greater than 1, that constituent will be designated a contaminant of concern, and further evaluation or investigation will be required. In instances where each constituent-specific hazard quotient is less than 1 but their sum is greater than 1, the major toxicological effects of the individual constituents will be examined to determine the potential hazard associated with exposure to multiple constituents. As appropriate, those constituents with significant additive effects will be designated contaminants of concern.

A similar method will be used for the evaluating carcinogenic constituents. The exposure assumptions given in Section 1.2 will be used to calculate the constituent exposure level in milligrams per kilogram per day. The exposure levels for individual carcinogenic constituents present in a given environmental medium will be multiplied by the constituent-specific slope factor (either oral or inhalation, depending on the medium being evaluated) to obtain a risk value. The individual constituent risks will be summed to estimate total carcinogenic risk, using the following equation:

$$\text{Risk} = \hat{A}_{1}^{i}(E_i \times SF_i) \ ,$$

where

E_i = exposure level for the ith constituent

SF_i = slope factor for the ith constituent.

This medium-specific risk level will be compared with an acceptable risk level of 10^{-6}. In instances where the risk level from an individual constituent is greater than 10^{-6}, that constituent will be designated a contaminant of concern, and further evaluation or investigation will be required. In instances where each constituent-specific risk level is less than 10^{-6} but their sum is greater than 10^{-6}, the type of cancer associated with each constituent will be evaluated to determine whether summing risks is appropriate. Summed risks exceeding 10^{-6} may be considered acceptable in some cases because proposed Subpart S guidance indicates that risks from multiple constituents should be kept within the risk range of 10^{-4} to 10^{-6}.

1.4 Derivation of SALs for Other Media or Substances

Values analogous to SALs may be needed for evaluating substances that involve unique exposure considerations (e.g., structural surfaces and debris, shrapnel, high explosives, asbestos, asphalt). The methods that will be used to evaluate these substances are discussed in the following paragraphs.

1.4.1 Structural Surfaces and Debris

Proposed Subpart S does not provide guidance on the derivation of SALs for potentially contaminated structural surfaces or debris (e.g., concrete, wood). These

values may be needed for evaluating unused buildings. Plausible exposure routes for structural materials (i.e., demolition debris) that are currently buried or at the land surface are through human contact with the surrounding media (e.g., soil, water, air) because easily removable constituents would already have been released as the result of weathering processes. Therefore, nonradiological contamination from exposed and buried structural debris can be evaluated by comparing SALs with constituent levels in surrounding media. Appropriate SALs are being developed for sediments and liquids present in buried pipes and tanks.

The structural surfaces of unused buildings may contain removable nonradiological constituents because these surfaces have not been subjected to weathering processes. SALs for these structural surfaces may be derived using wipe test data and appropriate assumptions on dust resuspension rates, inhalation and ingestion rates, and exposure period. These SALs for structural surfaces will be derived on an as-needed basis when characterization data become available.

1.4.2 Other Media and Substances

Special consideration is needed for shrapnel and unexploded high explosives that are present in some operable units. The primary health hazard associated with these materials is damage by explosion. Toxicity from chemicals that might be released from these materials will be evaluated for individual constituents using appropriate SALs for soil, water, air, and structural surfaces. The work plans for individual operable units will address characterization of sites with respect to shrapnel and high explosives, as needed.

Other special substances include asbestos and asphalt demolition materials. The SAL approach developed for evaluating most other constituents may not be appropriate for these contaminants; federal and state guidance is being sought for evaluation of these special substances.

2.0 CRITERIA FOR RADIOLOGICAL CONSTITUENTS

This section will be provided in the next revision of the IWP.

TABLE J-1

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Listed Substances[b]	Chronic Oral RfD mg/kg-day	Oral Slope Factor (mg/kg-d)$^{-1}$ and Group[c]	Chronic Inhalation RfD mg/kg-d	Inhalation Slope Factor (mg/kg-d)$^{-1}$ and Group[c]	VF[k] m^3/kg	Soil Screening Action Level Systemic Toxicant mg/kg	Soil Screening Action Level Carcinogen mg/kg	Water Screening Action Level Systemic Toxicant µg/l	Water Screening Action Level Carcinogen µg/l	Air Screening Action Level Systemic Toxicant µg/m^3	Air Screening Action Level Carcinogen µg/m^3	CRQL[d] mg/kg and µg/l
Target Analyte List												
Aluminum[e], 7429-90-5												40, 200
Antimony, 7440-36-0	0.0004					32		14				12, 609
Arsenic, 7440-38-2	0.0003[j]	1.75, A		15, A		24	0.40	11	0.02		0.00023	2, 109
Barium, 7440-39-3	0.07		0.00014[f]			5,600		2,400		0.49		40, 200
Beryllium, 7440-41-7	0.005	4.3, B2		8.4, B2		400	0.16	170	0.0081		0.00042	1, 59
Cadmium, 7440-43-9	0.001[m]			6.3, B1		80		35			0.00056	1, 5
Calcium[e], 7440-70-2												1000, 5000
Chromium III, 16065-83-1	1.0					80,000		35,000				2, 10
Chromium VI, 7440-47-3	0.005			42, A		400		170			0.000083	2, 10
Cobalt[e], 7440-48-4												10, 50
Copper, 7440-50-8	0.037[f]					3,000		1,300				5, 25
Cyanide, 57-12-5	0.02				8.2e+03	1,600		700				2, 10
Iron[e], 1543-83-10												20, 100
Lead[e], 7439-92-1												0.6, 3
Magnesium[e], 7786-30-3												1000, 5000
Manganese, 7439-96-5	0.1	ND, D	0.00011	ND, D		8,000		3,500		0.39		3, 15

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Listed Substances[b]	Chronic Oral RfD mg/kg-day	Oral Slope Factor (mg/kg-d)$^{-1}$ and Group[c]	Chronic Inhalation RfD mg/kg-d	Inhalation Slope Factor (mg/kg-d)$^{-1}$ and Group[c]	VF[k] m^3/kg	Soil Screening Action Level Systemic Toxicant mg/kg	Soil Screening Action Level Carcinogen mg/kg	Water Screening Action Level Systemic Toxicant µg/l	Water Screening Action Level Carcinogen µg/l	Air Screening Action Level Systemic Toxicant µg/m^3	Air Screening Action Level Carcinogen µg/m^3	CRQL[d] mg/kg and µg/l
Mercury, 7439-97-6	0.0003[f]	ND, D	8.6e-5[f]	ND, D		24		11		0.30		0.04, 0.2
Nickel, 7440-02-0	0.02			0.84, A		1,600		700			0.0042	8, 40
Potassium[e], 7447-40-7												1000, 5000
Selenium, 7782-49-2	0.005					400		170				1, 5
Silver, 7440-22-4	0.005					400		170				2, 10
Sodium[e], 7647-14-5												1000, 5000
Thallium, 7440-28-0	0.00008 n					6.4		2.8				2, 10[g]
Uranium[b], 7440-61-1	0.003					240		100				
Vanadium, 7440-62-2	0.007[f]					560		240				10, 50
Zinc, 7440-66-6	0.3[f]	ND, D		ND, D		24,000		10,000				4, 20
Target Compound List												
Volatile Organic Compounds												
Acetone, 67-64-1	0.1				1.4e+04	8,000		3,500				0.01, 10
Benzene, 71-43-2		0.029, A		0.029, A	5.7e+03		0.67[h]		1.2		0.12	0.01, 10[g]
Bromodichloromethane, 75-27-4	0.02	0.13, B2		ND, B2	8.0e+02	1,600	5.4	700	0.27			0.01, 10[g]

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Listed Substances[b]	Chronic Oral RfD mg/kg-day	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	Chronic Inhalation RfD mg/kg-d	Inhalation Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	VF[k] m^3/kg	Soil Screening Action Level Systemic Toxicant mg/kg	Soil Screening Action Level Carcinogen mg/kg	Water Screening Action Level Systemic Toxicant µg/l	Water Screening Action Level Carcinogen µg/l	Air Screening Action Level Systemic Toxicant $\mu g/m^3$	Air Screening Action Level Carcinogen $\mu g/m^3$	CRQL[d] mg/kg and µg/l
Bromoform, 75-25-2	0.02	0.0079, B2		0.0039, B2		1,600	89	700	4.4		0.90	0.01, 10[g]
Bromomethane, 74-83-9	0.0014		0.0014		3.9e+02	0.43[h]		49		4.9		0.01, 10
2-Butanone (Methyl ethyl ketone), 78-93-3	0.05[f]		0.29		1.9e+04	2,100[h]		1,700		1,000		0.01, 10
Carbon disulfide, 75-15-0	0.1		0.0029[f]		3.2e+03	7.4[h]		3,500		10		0.01, 10
Carbon tetrachloride, 56-23-5	0.0007	0.13, B2		0.053, B2	3.3e+03	56	0.21[h]	25	0.27		0.066	0.01, 10[g]
Chlorobenzene, 108-90-7	0.02		0.0057[f]		1.5e+04	67[h]		700		20		0.01, 10
Chloroethane, 75-00-3			2.9		1.4e+03	3,300[h]				10,000		0.01, 10
Chloroform, 67-66-3	0.01	0.0061, B2		0.081, B2	4.8e+03	800	0.21[h]	350	5.7		0.043	0.01, 10[g]
Chloromethane, 74-87-3		0.013, C[f]		0.0063, C[f]	1.2e+03		6.4[h]		27		5.6	0.01, 10
Dibromochloromethane, 124-48-1	0.02	0.084, C		ND, C		1,600	83	700	4.2			0.01, 10[g]
1,1-Dichloroethane, 75-34-3	0.1[f]	ND, C	0.14[f]	ND, C	3.8e+03	410[h]		3,500		500		0.01, 10
1,1-Dichloroethene, 75-35-4	0.009	0.6, C		0.12, C	2.1e+03	720	0.59[h]	310	0.58		0.29	0.01, 10[g]
1,2-Dichloroethane, 107-06-2		0.091, B2		0.091, B2	5.5e+03		0.20[h]		0.38		0.038	0.01, 10[g]
1,2-Dichloroethene (total), 540-59-0	0.01[f,i]				4.6e+03	800		350				0.01, 10
1,2-Dichloropropane, 78-87-5		0.068, B2[f]	0.0011	ND, B2[f]	7.1+03	6.5[h]	10		0.51	4.0		0.01, 10[g]

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Listed Substances[b]	Chronic Oral RfD mg/kg-day	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	Chronic Inhalation RfD mg/kg-d	Inhalation Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	VF[k] m^3/kg	Soil Screening Action Level Systemic Toxicant mg/kg	Soil Screening Action Level Carcinogen mg/kg	Water Screening Action Level Systemic Toxicant µg/l	Water Screening Action Level Carcinogen µg/l	Air Screening Action Level Systemic Toxicant $\mu g/m^3$	Air Screening Action Level Carcinogen $\mu g/m^3$	CRQL[d] mg/kg and µg/l
cis-1,3-Dichloropropene, 10061-01-5	0.0003	0.18, B2[f]	0.0057	0.13, B2[f]	6.8+03	14[h]	0.17[h]	11	0.19	20	0.027	0.01, 10[g]
trans-1,3-Dichloropropene, 10061-02-6	0.0003	0.18, B2[f]	0.0057	0.13, B2[f]	6.8+3	14[h]	0.17[h]	11	0.19	20	0.027	0.01, 10[g]
Ethyl benzene, 100-41-4	0.1	ND, D	0.29	ND, D	2.2e+04	3,100[h]		3,500		1000		0.01, 10
2-Hexanone[e], 591-78-6					5.5e+04							0.01, 10
4-Methyl-2-pentanone (MIK), 108-10-1	0.05[f]		0.023[f]		3.2e+04	510[h]		1,700		80		0.01, 10
Methylene Chloride, 75-09-2	0.06	0.0075, B2	0.86[f]	0.0016, B2	2.9e+03	1,400[h]	5.6[h]	2,100	4.7	3000	2.2	0.01, 10[g]
Styrene, 100-42-5	0.2				1.8e+04	16,000		7,000				0.01, 10[g]
1,1,2,2-Tetrachloroethane, 79-34-5		0.2, C		0.2, C	2.9e+04		3.9[h]		1.8		0.18	0.01, 10[g]
Tetrachloroethene, 127-18-4	0.01	0.052, B-C[o]		0.002, B-C[o]	6.0e+03	800	5.9[h]	350	0.67		1.8	0.01, 10[g]
Toluene, 108-88-3	0.2	ND, D	0.40	ND, D	1.1e+04	890[h]		7,000		380		0.01, 10
1,1,1-Trichloroethane, 71-55-6	0.09[f]	ND, C	0.29[f]	ND, C	5.1e+03	1,000[h]		3,100		1,000		0.01, 10
1,1,2-Trichloroethane, 79-00-5	0.004	0.057, C		0.056, C	1.1e+04	320	6.3[h]	140	6.1		0.63	0.01, 10[g]
Trichloroethene[e], 79-01-6		0.011, B-C[o]		0.006, B-C[o]	5.8e+03		3.2[h]		3.2		0.58	0.01, 10[g]
Vinyl Chloride, 75-01-4		1.9, A[f]		0.294, A[f]	1.1e+03		0.013[h]		0.018		0.012	0.01, 10[g]
Xylenes (Total), 1330-20-7	2				9.6e+03	160,000		70,000				0.01, 10

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Listed Substances[b]	Chronic Oral RfD mg/kg-day	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	Chronic Inhalation RfD mg/kg-d	Inhalation Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	VF[k] m^3/kg	Soil Screening Action Level Systemic Toxicant mg/kg	Soil Screening Action Level Carcinogen mg/kg	Water Screening Action Level Systemic Toxicant µg/l	Water Screening Action Level Carcinogen µg/l	Air Screening Action Level Systemic Toxicant $\mu g/m^3$	Air Screening Action Level Carcinogen $\mu g/m^3$	CRQL[d] mg/kg and µg/l
Semi-Volatile Organic Compounds												
Acenaphthene, 83-32-9	0.06				3.4e+05	4,800		2,100				0.33, 10
Acenaphthylene[e], 208-96-8					6.1e+04							0.33, 10
Anthracene, 120-12-7	0.3				1.8e+05	24,000		10,000				0.33, 10
Benzo[a]anthracene[e], 56-55-3		ND, B2		NA, B2								0.33, 10
Benzo[b]fluoranthene[e]205-99-2		ND, B2		ND, B2								0.33, 10
Benzo[k]fluoranthene[e], 207-08-9		ND, B2		ND, B2								0.33, 10
Benzo[ghi]perylene[e], 191-24-2		ND, D		ND, D								0.33, 10
Benzo[a]pyrene, 50-32-8		7.3, B2		6.1, B2[f]			0.10		0.0048		0.00057	0.33, 109
Bis(2chloroethoxy)methane[e], 111-91-1		ND, D		ND, D								0.33, 10
Bis-(2-chloroethyl)ether, 111-44-4		1.1, B2		1.1, B2	4.9e+04		0.13[h]		0.032		0.0032	0.33, 109
Bis(2-ethylhexyl)phthalate, 117-81-7	0.02	0.014, B2		ND, B2		1,600	50	700	2.5			0.33, 109
4-Bromophenyl-phenylether[e], 101-55-3												0.33, 10
Butyl benzyl phthalate, 85-68-7	0.2	ND, C		ND, C		16,000		7,000				0.33, 10
Carbazole, 86-74-8		0.02, B2[f]		ND, B2[f]			35		1.8			0.33, 10

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Listed Substances[b]	Chronic Oral RfD mg/kg-day	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	Chronic Inhalation RfD mg/kg-d	Inhalation Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	VF[k] m^3/kg	Soil Screening Action Level Systemic Toxicant mg/kg	Soil Screening Action Level Carcinogen mg/kg	Water Screening Action Level Systemic Toxicant µg/l	Water Screening Action Level Carcinogen µg/l	Air Screening Action Level Systemic Toxicant $\mu g/m^3$	Air Screening Action Level Carcinogen $\mu g/m^3$	CRQL[d] mg/kg and µg/l
4-Chloroaniline, 106-47-8	0.004					320		140				0.33, 10
4-Chloro-3-methylphenol (p-chloro-m-cresol), 59-50-7	2[f, j]					160,000		70,000				0.33, 10
2-Chloronaphthalene, 91-58-7	0.08				1.4e+05	6,400		2,800				0.33, 10
2-Chlorophenol, 95-57-8	0.005					400		170				0.33, 10
4-Chlorophenyl phenyl ether[e], 7005-72-3												0.33, 10
Chrysene[e], 218-01-9		ND, B2		ND, B2								0.33, 10
Dibenz[a,h]anthracene[e], 53-70-3		ND, B2		ND, B2								0.33, 10
Dibenzofuran[e], 132-64-9												0.33, 10
Di-n-butylphthalate, 84-74-2	0.1	ND, D		ND, D		8,000		3,500				0.33, 10
1,2-Dichlorobenzene, 95-50-1	0.09		0.057[f]		4.5e+04	1,600[h]		3,100		200		0.33, 10
1,3-Dichlorobenzene[e], 541-73-1					3.3e+04							0.33, 10
1,4-Dichlorobenzene, 106-46-7		0.024, C[f]	0.2[f]	ND, C	3.6e+04	5,800[h]	290		15	700		0.33, 10
3,3-Dichlorobenzidine, 91-94-1		0.45, B2		ND, B2			1.6		0.078			0.33, 10[g]
2,4-Dichlorophenol, 120-83-2	0.003					240		100				0.33, 10
Diethylphthalate, 84-66-2	0.8					64,000		28,000				0.33, 10
2,4-Dimethylphenol, 105-67-9	0.02			ND, D	1.1e+05	1,600		700				0.33, 10
Dimethyl phthalate, 131-11-3	1[f]	ND, D		ND, D		80,000		35,000				0.33, 10

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Listed Substances[b]	Chronic Oral RfD mg/kg-day	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	Chronic Inhalation RfD mg/kg-d	Inhalation Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	VF[k] m^3/kg	Soil Screening Action Level Systemic Toxicant mg/kg	Soil Screening Action Level Carcinogen mg/kg	Water Screening Action Level Systemic Toxicant µg/l	Water Screening Action Level Carcinogen µg/l	Air Screening Action Level Systemic Toxicant $\mu g/m^3$	Air Screening Action Level Carcinogen $\mu g/m^3$	CRQL[d] mg/kg and µg/l
4,6-Dinitro-2-methylphenol[e] (4,6-dinitro-o-cresol), 534-52-1												0.8, 25
2,4-Dinitrophenol, 51-28-5	0.002					160		70				0.8, 25
2,4-Dinitrotoluene, 121-14-2		0.68, B2		ND, B2			1.0		0.051			0.33, 10[g]
2,6-Dinitrotoluene, 606-20-2		0.68, B2		ND, B2			1.0		0.051			0.33, 10[g]
Di-n-octyl phthalate, 117-84-0	0.02[f]					1,600		700				0.33, 10
Fluoranthene, 206-44-0	0.04					3,200		1,400				0.33, 10
Fluorene, 86-73-7	0.04				5.1e+05	3,200		1,400				0.33, 10
Hexachlorobenzene, 118-74-1	0.0008	1.6, B2		1.6, B2		64	0.44	28	0.022		0.0022	0.33, 10[g]
Hexachlorobutadiene, 87-68-3	0.002	0.078, C		0.077, C		160	90	70	4.5		0.45	0.33, 10[g]
Hexachlorocyclopentadiene, 77-47-4	0.007		0.00002[f]			560		240		0.07		0.33, 10
Hexachloroethane, 67-72-1	0.001	0.014, C		0.014, C		80	500	35	25		2.5	0.33, 10
Indeno[1,2,3-cd]pyrene[e], 193-39-5		ND, B2		ND, B2								0.33, 10
Isophorone, 78-59-1	0.2	0.00095		ND, C		16,000	7,400	7,000	370			0.33, 10
2-Methylnaphthalene[e], 91-57-6					1.9e+05							0.33, 10
2-Methylphenol (o-cresol), 95-48-7	0.05	ND, C		ND, C		4,000		1,700				0.33, 10
4-Methylphenol (p-cresol), 106-44-5	0.05[f]	ND, C		ND, C		4,000		1,700				0.33, 10

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Listed Substances[b]	Chronic Oral RfD mg/kg-day	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	Chronic Inhalation RfD mg/kg-d	Inhalation Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	VF[k] m^3/kg	Soil Screening Action Level Systemic Toxicant mg/kg	Soil Screening Action Level Carcinogen mg/kg	Water Screening Action Level Systemic Toxicant µg/l	Water Screening Action Level Carcinogen µg/l	Air Screening Action Level Systemic Toxicant $\mu g/m^3$	Air Screening Action Level Carcinogen $\mu g/m^3$	CRQL[d] mg/kg and µg/l
Naphthalene, 91-20-3	0.04[f]				6.8e+04	3,200		1,400				0.33, 10
2-Nitroaniline, (o-nitroaniline) 88-74-4	6.0e-05[f]		5.7e-05[f]			4.8		2.1		0.20		
3-Nitroaniline(m-nitroaniline)[e], 99-09-2												0.8, 25
4-Nitroaniline(p-nitroaniline)[e], 100-01-6												0.8, 25
Nitrobenzene, 98-95-3	0.0005	ND, D	0.00057[f]	ND, D	1.3e+04	5.3[h]		18		2.0		0.33, 10
2-Nitrophenol[e], 88-75-5												0.33, 10
4-Nitrophenol[e], 100-02-7					1.9e+04							0.8, 25
N-Nitrosodiphenylamine, 86-30-6		0.0049, B2		ND, B2			140		7.1			0.33. 10[g]
N-Nitroso-di-N-dipropylamine, 621-64-7		7, B2		ND, B2			0.10		0.0050			0.33, 10[g]
2,2-Oxybis(1-chloropropane) (bis[2-chloroisopropyl]ether), 108-60-1	0.04	0.07[f], C		0.035, C[f]		3,200	100	1,400	0.50		1.0	0.33, 10
Pentachlorophenol, 87-86-5	0.03	0.12, B2		ND, B2		2,400	5.8	1,000	0.29			0.8, 25[g]
Phenanthrene[e], 85-01-8					4.4e+05							0.33, 10
Phenol, 108-95-2	0.6					48,000		21,000				0.33, 10
Pyrene, 129-00-0	0.03					2,400		1,000				0.33, 10

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Listed Substances[b]	Chronic Oral RfD mg/kg-day	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	Chronic Inhalation RfD mg/kg-d	Inhalation Slope Factor $(mg/kg\text{-}d)^{-1}$ and Group[c]	VF[k] m^3/kg	Soil Screening Action Level Systemic Toxicant mg/kg	Soil Screening Action Level Carcinogen mg/kg	Water Screening Action Level Systemic Toxicant µg/l	Water Screening Action Level Carcinogen µg/l	Air Screening Action Level Systemic Toxicant $\mu g/m^3$	Air Screening Action Level Carcinogen $\mu g/m^3$	CRQL[d] mg/kg and µg/l
1,2,4-Trichlorobenzene, 120-82-1	0.01		0.0026[f]		9.5e+04	160[h]		350		9.0		0.33, 10
2,4,5-Trichlorophenol, 95-95-4	0.10					8,000		3,500				0.8, 25
2,4,6-Trichlorophenol, 88-06-2		0.011, B2		0.011, B2			64		3.2		0.32	0.33, 109

a. Screening action levels based on methodologies given by EPA (1990, 0432; and 1991, 0778). Reference dose (RfD) and slope factor data obtained from EPA(1992, 0830), unless otherwise noted. Screening action levels are rounded to two significant figures. Water screening action levels are used for both groundwater and surface water. ND = not determined.
b. Target Analyte List (TAL) and Target Compound List (TCL) and CAS numbers, as given by EPA (1991, 0778; 1991, 0779). Uranium has also been included because it is expected to be a contaminant of concern in some areas.
c. Carcinogens grouped as follows: Group A—human carcinogen; Group B—probable human carcinogen; Group C—possible human carcinogen; Group D—not classifiable as to human carcinogenicity.
d. Contract-Required Quantitation Limits (CRQLs) for soil and water, respectively. For TAL substances, CRQL for soil is obtained by multiplying water CRQL by 0.2. For TCL substances, the soil CRQL given is for low soil samples (wet weight). CRQLs not available for air.
e. Toxicity data (e.g., RfDs and/or slope factors) were not available; therefore, screening action levels were not calculated.
f. Toxicity data obtained from EPA (1992, 0833).
g. The screening action level is less than the CRQL; therefore, special analytical services may be required.
h. Soil screening action level incorporates inhalation pathway (only for substances with both an inhalation RfD or slope factor and a volatilization factor (VF) listed). See below for equation.
i. Oral RfD for cis-1,2-Dichloroethene used.
j. Subchronic RfD; chronic RfD for 4-chloro-3-methylphenol not available.
k. Soil-to-air volatilization factor; calculated based on equation given by EPA (1991, 0778), and chemical-specific parameters given by Strenge and Peterson (1989, 0777) and EPA (1988, 0747). VF is given only for substances with molecular weight less than 200 and Henry's Law constant greater than 10^{-5} atm/m^3-mole.

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

l. Oral RfD for arsenic taken from EPA (1992, 0830).
m. Oral RfD for cadmium in food/solids.
n. Oral RfD for thallium (I) sulfate.
o. Values obtained from the Superfund Health Risk Technical Support Center, Cincinnati, Ohio, October 1992.

General Equations for Calculation of Screening Action Levels

Systemic Toxicants

SAL = (THI x RfD x BW x CF)/(I x A), where

SAL = soil screening action level (mg/kg for soil SALs; µg/L for water SALs; µg/m^3 for air SALs).
THI = Target Hazard Index; 1
RfD = chronic reference dose (mg/kg/day); oral RfD used for soil and water SALs; inhalation RfD used for air SAL.
BW = body weight; 16 kg for child (used for soil SAL); 70 kg for adult (used for water and air SALs)
CF = conversion factor; 10^6 mg/kg for soil SAL; 1000 ug/mg for water and air SALs.
I = intake assumption; 200 mg/day for soil SAL (child); 2L/day for water SAL; 20 m^3/day for air SAL.
A = absorption factor; 1

Carcinogenic Constituents

SAL = (R x BW x LT x CF)/(SF x I x A x ED), where

R = target risk; 10^{-6} for Class A and B carcinogens; 10^{-5} for Class C carcinogens.
BW = body weight; 70 kg
LT = assumed lifetime; 70 yrs.
CF = conversion factor; 10^6 mg/kg for soil SAL; 1000 µg/mg for water and air SALs.
SF = slope factor $(mg/kg/day)^{-1}$; oral SF used for soil and water SALs; inhalation SF used for air SALs.
I = intake assumption; 100 mg/day for soil SAL; 2L/day for water SAL; 20 m^3/day for air SAL.
A = Absorption factor; 1.
ED = exposure duration; 70 yrs.

TABLE J-1 (continued)

SCREENING ACTION LEVELS FOR CHEMICAL ANALYTES IN SOIL, WATER, AND AIR FOR ENVIRONMENTAL CHARACTERIZATION OF LOS ALAMOS NATIONAL LABORATORY[a]

Equations for calculation of soil screening action levels for volatile contaminants

Systemic Toxicants

$$SAL = (THI \times BW)/((1/RfD_o \times 10^{-6}\ kg/mg \times ING) + (1/RfD_i \times INH \times (1/VF + 1/PEF))$$

where

THI = target hazard index; 1
BW = body weight; 16 kg
RfD_o = chronic oral reference dose (mg/kg/day)
RfD_i = chronic inhalation reference dose (mg/kg/day)
ING = ingestion intake assumption; 200 mg/day
VF = soil-to-air volatilization factor (m^3/kg; chemical-specific)
INH = inhalation intake assumption; 20 m^3/day
PEF = particulate emission factor (4.63×10^9 m^3/kg; EPA 1991c)

Carcinogens

$$SAL = (R \times BW \times LT)/ED \times [(SF_o \times 10^{-6}\ kg/mg \times ING) + (SF_i \times INH \times (1/VF + 1/PEF))]$$

where

R = target risk; 10^{-6} for Class A and B carcinogens; 10^{-5} for Class C carcinogens
BW = body weight; 70 kg
LT = assumed lifetime; 70 years
ED = exposure duration; 70 years
SF_o = oral slope factor $(mg/kg/day)^{-1}$
ING = ingestion intake assumption; 100 mg/day
SF_i =inhalation slope factor $(mg/kg/day)^{-1}$
INH = inhalation intake assumption; 20 m^3/day
VF and PEF as defined above

TABLE J-2

SAFE DRINKING WATER ACT MAXIMUM CONTAMINANT LEVELS AND NEW MEXICO WATER QUALITY CONTROL COMMISSION GROUNDWATER STANDARDS

Substance	SDWA MCL (µg/L)	State of New Mexico Standard (µg/L)
TAL[a]		
Arsenic	50	100
Barium	2,000	1,000
Cadmium	5	10
Chromium III	100	50
Chromium IV	100	50
Cyanide		200
Lead	50	50
Mercury	2	2
Selenium	50	50
Silver	50	50
Uranium		5,000
TCL[b]		
Benzene	5	10
Benzo[a]pyrene		0.70
Carbon Tetrachloride	5	10
Chlorobenzene	100	
Chloroform		100
1,2-Dichlorobenzene	600	
1,4-Dichlorobenzene	75	
1,1-Dichloroethane		25
1,2-Dichloroethane	5	10
1,1-Dichloroethene	7	5
cis-1,2-Dichloroethene	70	
trans-1,2-Dichloroethene	100	
1,2-Dichloropropane	5	
Ethyl Benzene	700	750
Methylene Chloride		100
Naphthalene		30
Styrene	100	
Tetrachloroethene	5	20
1,1,2,2-Tetrachloroethane		10
Toluene	1,000	750
Trichloroethene	5	100
1,1,1-Trichloroethane	200	60
Vinyl Chloride	2	1
Xylene	10,000	620

a. Target Analyte List Substances (EPA 1991, 0778).
b. Target Compound List Substances (EPA 1991, 0079).

References for Appendix J

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■ APPENDIX K

Baseline Risk Assessment Methodology

DRAFT OUTLINE OF BASELINE RISK ASSESSMENT METHODOLOGY

EXECUTIVE SUMMARY

1.0 INTRODUCTION

1.1 Objectives of Baseline Risk Management Methodology
1.2 Organization of This Appendix
1.3 History of the Site
1.4 Physical Description of the Site
1.5 RFI/CMS Activities
1.6 Operable Unit SWMU Definitions

1.6.1 Operable Units
1.6.2 Solid Waste Management Units

2.0 PROGRAMMATIC APPROACH TO RISK ASSESSMENT

2.1 Objectives of Risk Assessments

2.1.1 Objectives of a Baseline Risk Assessment
2.1.2 Objectives of a CMS Risk Assessment

2.2 Operable Unit Risk Assessments

2.2.1 Operable Unit Baseline Risk Assessments
2.2.2 Operable Unit CMS Risk Assessments

2.3 Sitewide Assessments

2.3.1 Preliminary Sitewide Baseline Risk Assessment
2.3.2 CMS Comprehensive Response Action Risk Evaluations
2.3.3 Sitewide Projected Residual Risk Assessment
2.3.4 Sitewide CMS Risk Assessment

2.4 Risk Assessment Technical Approach

2.5 Presentation of Risk Assessments

2.5.1 General Risk Assessment Report Format

2.5.1.1 Baseline Risk Assessment Format
2.5.1.2 CMS Risk Assessment Format

2.5.2 Operable Unit RFI/CMS Risk Assessments

2.5.2.1 RFI Baseline Risk Assessments
2.5.2.2 CMS Risk Assessments

2.5.3 Sitewide RFI/Projected Residual Risk Assessment

3.0 OVERVIEW OF INFORMATION AND DATA USED IN RFI/CMS RISK ASSESSMENTS

3.1 Site Characterization Data
3.2 Fate and Transport Modeling Data
3.3 Exposure Assessment Data
3.4 Toxicity Data
3.5 Operable-Unit-Specific Parameter Needs
3.6 Uncertainties

4.0 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

4.1 Analysis of Data
4.2 Statistical Evaluation of Background
4.3 Selection Criteria and Action Levels
4.4 Potential Sources of Chemicals, Radionuclides, and High Explosives at the Laboratory

5.0 DEVELOPMENT OF EXPOSURE SCENARIOS

5.1 Characterization of Exposure Setting Physical Environment
5.2 Potentially Exposed Receptors

5.2.1 Current Land Use Scenarios
5.2.2 Future Land Use Scenarios
5.2.3 Exposure Scenarios

5.3 Characterization of Potential Exposure Pathways at the Laboratory/Conceptual Site Model

5.3.1 Potential Water Exposure Pathways
5.3.2 Potential Air Exposure Pathways
5.3.3 Potential Soil Exposure Pathways
5.3.4 Potential Sediment

5.4 Selection of Exposure Pathways (Conceptual Site Model)

5.4.1 Exposure Pathways from Water Sources/Sediment
5.4.2 Exposure Pathways from Air Sources
5.4.3 Soil/Waste Exposure Pathways

6.0 FATE AND TRANSPORT MODELING

6.1 Groundwater Geochemical Model
6.2 Modeling Surface Water Transport
6.3 Modeling Air Transport

6.4 Fate of Contaminants in Soil
6.5 Modeling Direct Radiation Exposure
6.6 Codes for Assessing Multiple Pathway

7.0 QUANTIFICATION OF EXPOSURE

7.1 Determination of Exposure Concentration

7.1.1 Measured Concentration
7.1.2 Derivation of Exposure Concentrations from Measured Data
7.1.3 Modeled Concentrations

7.2 Intake Assessment

7.2.1 Intake Models and Equations
7.2.2 Intake and Exposure Model Parameter Values
7.2.3 Quantitative Exposure Assessment Results

7.3 Radiation Dose Assessment

8.0 TOXICITY ASSESSMENT

8.1 Toxicity Information for Noncarcinogenic Effects
8.2 Toxicity Information for Carcinogenic Effects
8.3 Combined Health Effects from Mixed Waste

8.3.1 Regulatory Guidance
8.3.2 Health Effects from Exposures to Mixed Wastes
8.3.3 Conclusions

8.4 Uncertainties Related to Toxicity Information

9.0 RISK CHARACTERIZATION

9.1 Risk Characterization for RFI Baseline Risk Assessments
9.2 Risk Characterization Methodolgy

9.2.1 Hazardous Chemical Risks
9.2.2 Radiological Exposures

9.3 Presentation of Risk Characterization Results
9.4 Uncertainties Associated with Risk Assessments

10.0 RISK ASSESSMENT/RISK MANAGEMENT IN THE CORRECTIVE MEASURES STUDY PROCESS

10.1 Remedial Action Objectives

10.1.1 Preliminary Remediation Goals

10.2.2 Final Remediation Goals

10.2 Corrective Measures Study Risk Assessment Characteristics

10.2.1 Overall Protection of Human Health and Environment
10.2.2 Long-Term Effectiveness and Performance
10.2.3 Short-Term Effectiveness

10.2.3.1 Risks to the Public During Remediation
10.2.3.2 Risks to Workers During Remediation

10.2.4 Risk Assessment for an Onsite Waste Management Facility

REFERENCES

■ APPENDIX L

List of Standard Operating Procedures for Implementation of Environmental Restoration Program at Los Alamos National Laboratory

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LANL-ER-SOP-01.04,R0	Sample Control and Field Documentation
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3.0	**RECONNAISSANCE/FIELD SURVEYS**
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LANL-ER-SOP-06.02,R0	Field Analytical Measurements of Groundwater Samples
LANL-ER-SOP-06.03,R0	Sampling for Volatile Organics
LANL-ER-SOP-06.04,R0	Sampling Commercial/Municipal/Domestic Wells
LANL-ER-SOP-06.05,R0	Soil Water Samples
LANL-ER-SOP-06.06.R0	Tensiometer (Soil Suction Monitor) Installation and Measurement
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LANL-ER-SOP-11.03,R0	Permeability of Granular Soils
LANL-ER-SOP-11.04,R0	Soil and Core pH
LANL-ER-SOP-11.05,R0	Total Organic Carbon
LANL-ER-SOP-11.06,R0	Cation-Exchange Capacity

■ APPENDIX M

Education and Experience of Environmental Restoration Program Staff

EDUCATION AND RELEVANT EXPERIENCE OF ER PROGRAM STAFF

Name and Affiliation	Education/Expertise	ER Program Assignment
Steve Slaten (DOE-LAAO)	B.S. Geology and Petroleum Engineering Manager 10 years experience in environmental engineering, including regulatory waste management enforcement and compliance, and management of investigations of inactive sites	DOE Project
Tom Gunderson (EM-DO)	Ph.D. Environmental Engineering 16 years experience in environmental surveillance, assessment, and regulatory compliance, including management	Division Leader
Bob Vocke (EM-13)	Ph.D. Water Resources 16 years experience in environmental and hazardous waste site assessment, including waste management, regulatory compliance, and program management	Program Manager, EM-13 Group Leader
Lars Soholt (EM-13)	Ph.D. Biology Leader 20 years experience in assessment of energy and waste management systems, including project management experience	Deputy Group
Paul Aamodt (EM-13)	B.S. Geology M.A. Management 20 years experience in geosciences, including site characterization, radioactive and hazardous waste management and disposal, and project management	Senior Programmatic Project Project Leader
Jim Aldrich (EES-1)	Ph.D. Geology Project Leader 17 years experience in geosciences research and environmental sciences, including project management planning and scheduling	Programmatic

Susan Alexander (HS-5)		Technical Team Leader, Health and Safety
Garry Allen (CLS-6)	B.S. Electrical Engineering 20 years experience in engineering design, 15 years experience in technical project management, 10 years experience in technical line management	Operable Unit Project Leader
Betsy Barnett (IS-11)	B.A. Languages 12 years experience writing and editing documents pertaining to the environment and radioactive waste disposal	Technical Team Leader, Document Production
David Broxton (EES-1)	M.S. Geology 15 years experience in petrologic and and geochemical studies of volcanic rocks, geologic disposal of high-level nuclear waste, and project management	Principal Investigator, Geology
Kathy Campbell (A-1)	Ph.D. Mathematics 12 years experience with statistical sampling/presentation/evaluation of geochemical and hazardous waste/ chemistry data	Technical Team Leader, Statistics
Allen Cogbill (EES-3)	Ph.D. Geological Sciences 15 years experience acquiring and analyzing detailed surface and subsurface geophysical data, especially potential field and seismic data	Principal Investigator, Geophysics
Greg Cole (EES-1)	Ph.D. Geosciences 13 years experience with computerized integration and analysis of field technical data from earth sciences, project management experience	Facility for Information Management, Analysis, and Display Project Leader
Micheline Devaurs (EM-13)	M.S. Hydrology 10 years experience in evaluation of environmental contamination, hydrologic modeling and field sampling, and project management	Programmatic Project Leader

Jean Dewart (EM-8)	M.S. Atmospheric Sciences 14 years experience in dispersion modeling and air quality regulations	Technical Team Leader, Air Quality
Alison Dorries (HS-5)	Ph.D Chemistry, M.P.H. Public Health 5 years experience in toxicology, pulmonary health research, regulation development, and environmental health risk assessment	Technical Team Leader, Human Health Risk Assessment
Keith Dowler (CLS-1)	B.S. Metallurgical Engineering 15 years experience in handling and examining irradiated material and management experience, 2 years experience in environmental restoration project management	Operable Unit Project Leader
Barry Drennon (EM-13)	14 years experience in analytical chemistry, 4 years in records management and archive investigations	Records/ Information Technician
Gary Eller (INC-DO)	Ph.D. Chemistry 18 years experience at Los Alamos in transuranic chemistry, process chemistry, co-contaminant environmental chemistry, and environmental project management	Operable Unit Project Leader
Harry Ettinger (EM-DO)	M.S. Civil Engineering 30 years experience in industrial hygiene and environmental protection	Program Manager for Technical Development
Roger Ferenbaugh (EM-DO)	B.S., M.S. Chemical Engineering Ph.D. Ecology/Environmental Science 22 years experience in ecological impact analysis, environmental chemistry, environmental surveillance and monitoring, and environmental regulatory compliance	Program Manager for Technical Development
Bill Foley (ENG-1)	B.S. Mechanical Engineering 36 years experience in facilities engineering	Construction Project Manager, Mixed Waste Storage and Disposal Facility
Bruce Gallaher (EM-8)	M.S. Hydrology 15 years experience in contaminant hydrology and regulatory compliance, including management of waste site characterization studies	Principal Investigator, Hydrology

Jamie Gardner (EES-1)	B.S. Earth Science, Ph.D. Geology 17 years experience in evaluating geologic hazards at nuclear facilities, 13 years in developing and managing large interdisciplinary earth science programs in a research on the tectonics, magmatism, and geohydrology of the Jemez Mountains and Pajarito Plateau	Technical Team Leader, Earth Sciences; Principal Investigator, Framework Studies
Doris Garvey (EM-8)	M.S. Economics 25 years experience in economic and environmental regulatory analysis, including 15 years in environmental assessments and impact analysis, 3 years of environmental regulatory compliance management, and 3 years as manager for the Laboratory's National Environmental Policy Act program	Technical Team Leader, Environmental Assessment
Bob Gilkeson (Weston)	M.S. Earth Science 20 years experience in the characterization of hazardous waste sites, including contaminant hydrology, surface geophysics, borehole geophysics, drilling programs, and regulatory compliance	Senior Technical Consultant
Bob Gillis (MEE-4)	B.S. Mechanical Engineering A.S. Electronic Engineering 25 years experience in engineering, including project management	Technical Team Leader for the Management Information System
Tracy Glatzmaier (EES-5)	B.S. Chemical Engineering, M.S. Industrial Engineering (Engineering Management Option) 7 years experience in engineering and project design and management; data acquisition and analysis in atmospheric transport and diffusion; 4 years management experience	Programmatic Project Leader
Sue Goff (EES-1)	M.S. Geology 15 years experience in geosciences, including designing, organizing, and managing drilling, geophysical logging, and curation management operations	Technical Team Leader, Drilling and Logging

Robert Gonzales (EM-13)	B.U.S. (Bachelor of University Studies) Environmental Science 16 years experience in regulatory compliance and environmental assessments, including hazardous waste site characterization, waste management, and project management	Project Leader for Engineering Project Review
Gene Gould (MEE-4)	B.A. History; additional formal course work in accounting and business law; 20 years experience in program management and development, resource management, and federal grant administration	Operable Unit Project Leader
Ed Griggs (CLS-DO)	B.S. Mechanical Engineering 29 years experience at Los Alamos, including nuclear reactor design, laser systems design, project management, initiation and management of CLS Division research and development contracts	Operable Unit Project Leader
Sharad Kelkar (EES-14)	M.S. Petroleum Engineering, M.S. Physics 12 years experience in fluid flow through porous media; recently worked as an operable unit project leader on a CERCLA site	Operable Unit Project Leader
Elizabeth J. Kelly (A-1)	Ph.D. Biostatistics 3 years experience in devising sampling plans and data analysis techniques for environmental studies, including surface covers, site integrity, and decision analysis for ER programs	Programmatic Project Leader, for Environmental Assessments Technical Teams
Craig Leasure (EM-9)	Ph.D. Analytical Chemistry 6 years experience as manager of chemistry performing analysis for ER Program	Technical Team Leader, Analytical Laboratory Instrumentation
Pat Longmire (INC-9)	Ph.D. Geochemistry: emphasis in low-temperature aqueous chemistry 15 years experience in geochemical aspects of radionuclide, inorganic, and organic solute migration	Operable Unit Project Leader; Principal Investigator, Geochemistry

Larry Maassen (EM-13)	M.S. Exploration Geology 12 years experience in exploration geology and 6 years in radioactive waste programs quality assurance and management	Programmatic Project Leader
Calvin Martell (CLS-1)	M.S. Analytical Chemistry 22 years experience in analytical chemistry and 1 year experience in the Environmental Restoration Program as deputy operable unit project leader	Operable Unit Project Leader
Brad Martin (CLS-DO)	B.S. Electrical Engineering, M.B.A. 12 years experience in electronic manufacturing; 8 years in facilities, safety, property, and financial management, including experience as health and safety officer and 1 year managing RCRA field investigation process	Operable Unit Project Leader
Dave McInroy (EM-13)	B.S. Biology 9 years experience in waste management activities, including 4 years of project management and three years as a regulatory compliance technical team leader	Programmatic Project Leader, Regulatory Compliance
Roy Michelotti (CLS-DO)	B.S. Mechanical Engineering, M.B.A. 13 years experience in engineering design and project management, 1 year in facility management and as health and safety officer	Operable Unit Project Leader
John Miglio (EM-9)	Ph.D. Chemistry 14 years experience in radiochemistry, 5 years experience in analytical chemistry, and 1 year experience in sample management	Technical Team Leader, Sample Coordination Facility
Dean Nelson (MEE-4)	B.S. Mechanical Engineering 33 years experience in the nuclear field, including 19 years in waste management and 13 years in project management	Technical Team Leader, Mixed Waste Storage and Disposal Facility

Carl Newton (EES-3)	Ph.D. Geophysics 30 years experience in geophysics; assignments include section leader at Los Alamos and program manager at DOE Headquarters	Operable Unit Project Leader
Ted Norris (EM-13)	Ph.D. Chemistry 12 years experience in radionuclide migration, 3 years experience in atmospheric pollutant transport, 3 years experience as health and safety officer, and 2 years experience in environmental restoration project management	Programmatic Project Leader
Al Ogard (INC-9)	Ph.D. Inorganic Chemistry Approximately 12 years experience experience at Los Alamos in research on the thermodynamic of nuclear materials, 19 years involved in the Yucca Mountain and Radionuclide Migration projects, and 2 years in the DOE Office of Arms Control in Washington as a technical expert assigned to the Threshold Test Ban Treaty negotiations	Operable Unit Project Leader
Al Pratt (EES-13)	B.S. Forestry, B.S. Environmental Science, M.B.A. 10 years experience in resource management; 5 years experience in radioactive waste management program, including project management	Operable Unit Project Leader
Mike Ray (EM-13)	B.S. Geology 21 years experience in geosciences, including 9 years experience in waste-related site assessment and information management for technical baseline design documents	Programmatic Project Leader
Cheryl Rofer (EES-1)	M.S. Organic Chemistry 5 years experience in developing technology for environmental remediations; 20 years experience in explosives, uranium, laser, and fossil fuel chemistry	Operable Unit Project Leader
Marja Shaner (EM-13)	A.A. Arts and Humanities (foreign languages) A.A. Paralegal Studies (emphasis on litigation and environmental law)	Administrative Liaison

	3 years experience in law office management, 6.5 years in Laboratory Counsel/General Law Office, with specialty in environmental law, policy and procedure development for General Law Office	
Everett Springer (EES-13)	Ph.D. Watershed Science 11 years experience in hydrology, including analysis of surface and subsurface flow and contaminant transport	Operable Unit Project Leader
Pat Trujillo-Oviedo (PA-3)	B.S. Agricultural Biology, M.S. Microbial Ecology, M.S. Interdisciplinary Toxicology 5 years experience as environmentalist coordinating public involvement programs, 2 years as community relations specialist in public affairs	Community Relations Project Leader
Ines Triay (INC-11)	Ph.D. Chemistry 7 years experience in environmental science, extensive experience in the study of actinide and fission product migration in the subsurface and design and evaluation of remediation techniques for removing actinides from soils and water	Operable Unit Project Leader
Sandra Wagner (EM-13)	M.S. Organic/Analytical Chemistry 9 years experience in implementing and managing assessment and remediation activities for hazardous waste sites	Operable Unit Project Leader
Karen Warthen (EM-13)	A.A. Education 37 hours towards B.S. English/ Technical Writing 12 years experience in management, including 10 years managing small business, 8 years records management and 3 years training coordination, 5 years quality assurance program integration	Quality Programmatic Project Leader

■ APPENDIX N

Projected Schedule and Cost of the Environmental Restoration Program at Los Alamos National Laboratory

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION
FY 1992 COST PLAN ($K)

PROJECT NAME: LOS ALAMOS NATIONAL LABORATORY	SUBMITTED BY: R. VOCKE	CONTRACTOR RESPONSIBLE: UNIVERSITY of CALIFORNIA
DATE: 1992.06.29	REPORTING LEVEL: ADS	CURRENT PERIOD: 1.Sep 92 TO 30.Sep 92

WBS	TASK		PRIOR FY's TOTAL	PLANNED DOLLARS ($K) CURRENT FISCAL YEAR: 1992 OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	BUDGET YEAR FY93	FIVE YEAR PLAN WINDOW FY94	FY95	FY96	FY97	FY98	BUDGET AT COMPLETION
	1049	Canyons Assessment	643	9	7	8	9	7	8		8	9	9	9	7	100	860	1079	3193	13833	21,574	26,598	132398
	1062	Interim Rem Assessment	1285	126	103	114	104	0	0		0	0	0	0	0	447	0	0	0	0	0	0	1732
	1063	Interim Rem UST's	920	37	31	34	36	32	37	38	34	37	38	36	36	426	0	0	0	0	0	0	1346
	1066	NEPA Documentation	184	0	0	0	0	0	0	5	17	19	19	18	18	96	500	2535	1194	0	0	0	4509
	1067	RCRA MWSDF	1044	53	44	45	32	35	70	129	117	129	148	63	225	1090	2670	2605	5485	7439	17	0	20350
	1071	TA-0, 19, 26, 73, 74 Assess	1028	59	272	114	172	25	20	78	82	97	97	181	200	1397	2789	14257	4450	16022	9,520	1,382	53192
	1078	TA-1 Assessment	782	162	245	102	58	43	57	39	158	172	163	164	205	1568	3218	1590	5556	1242	1,208	732	18123
	1079	TA-10, 31, 32, 45 Assess	1048	141	119	128	232	63	88	74	38	84	313	161	186	1627	1560	8044	5203	1140	467	746	20865
	1082	TA-11,13,16,24,25,28,37	0	62	43	48	95	79	134	143	153	200	156	195	192	1500	2018	2500	15674	16000	18,000	16,930	117650
	1085	TA-12, 14 ,67 Assessment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	483	532	6873	4584	3,433	692	18427
	1086	TA-15 Assessment	0	25	21	40	50	40	60	70	88	127	135	181	63	900	1443	8438	5686	7973	7,988	2,009	37423
	1091	TA-16 Burning Ground	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31
	1093	TA-18, 27, 65 Assessment	0	67	64	76	86	78	129	155	49	10	10	10	16	750	475	6866	5766	3843	685	822	20540
	1098	TA-2, 41 Assessment	0	39	35	40	58	58	160	[illegible]	23	80	80	73	115	800	636	1541	579	1932	1,426	573	9423
	1100	TA-20, 53, 72 Assessment	0	0	0	0	0	0	0		0	0	0	0	0	0	1076	733	4648	2540	5,882	1,336	18976
	1106	TA-21, Assessment	2347	106	87	138	146	159	311	283	256	424	529	776	836	4051	4016	6728	7727	8450	7,349	6,165	52995
	1111	TA-6, 7, 22,40, 58, 62 Assess	406	53	54	59	85	85	104	264	112	56	66	106	106	1150	1560	4108	3426	5274	5,148	1,959	25762
	1114	TA-3,30,59,60,61,64 Assess	0	36	36	40	151	216	173	173	158	132	78	69	38	1300	881	1500	7717	8000	12,000	10,244	54311
	1122	TA-33, 70 Assessment	1334	37	55	98	100	39	23	14	20	15	47	29	15	492	2429	7684	5686	8938	2,072	506	31444
	1127	TA-35, WST OIL PITS CLSR	1106	8	7	6	0	0	0	0	0	0	0	50	50	121	0	0	0	0	0	0	1227
	1129	TA-4,5,35,42,48,52,55,63,66	1002	251	241	237	46	53	28	45	102	32	32	31	21	1119	3155	3500	6304	12972	7,461	2,663	41731
	1130	TA-36,68,71 Assessment	0	19	27	85	89	67	74	69	47	19	18	18	18	550	853	909	1585	586	410	667	6050
	1132	TA-39 Assessment	0	17	14	17	24	27	57	53	60	84	73	64	61	551	877	1500	17192	17302	20,000	15,217	83064
	1135	TA-40, Scrap Deton. Site Clsr	67	8	47	93	42	28	45	17	25	76	15	22	23	441	167	0	0	0	0	0	675
	1136	TA-43, Assessment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	210	497	534	543	565	4309
	1140	TA-46, Assessment	0	46	61	45	47	40	78	77	76	17	17	16	130	650	819	3086	2672	2277	748	820	12627
	1144	TA-49, Assessment	611	96	78	61	68	83	26	35	20	21	25	34	53	600	998	834	868	1238	1,202	422	6318
	1147	TA-50, Assessment	570	137	84	60	66	96	19	21	91	7	7	6	6	600	1201	5051	5997	1889	493	697	17225
	1148	TA-51, 54, Assess. MDAL	1736	247	202	270	113	158	92	187	111	75	81	79	74	1689	3585	4400	8542	9291	12,000	10,550	58644
	1150	TA-54 Area L Waste Oil	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75
	1154	TA-57 Assessment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	219	271	389	487	470	288	2868
	1157	TA-8, 9, 23, 69 Assessment	0	0	0	63	51	100	113	117	144	82	29	62	133	894	705	4755	5482	4456	1,301	909	21166
	2105	Tech Support -- Assessment	7432	932	762	847	901	815	944	943	858	944	943	901	901	10691	14759	21273	22766	22852	22315	23113	238703
	2106	Remediation Management	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2107	Assessment Management	12378	764	626	695	730	660	764	765	695	764	765	730	730	8687	10638	13155	13624	13246	13009	13404	153494
	2110	Analytical Chem. Bld Studies	145	144	20	23	21	17	13	11	10	10	11	10	10	300	0	1800	977	4225	9,555	1,396	18398
	2220	TA-53 Lagoon Closure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SUBTOTAL	PLAN	36174	3681	3384	3586	3612	3103	3628	3853	3552	3722	3904	4094	4468	44587	64690	131484	175758	198565	186276	141395	1308071
		FYTD PLAN		3681	7065	10651	14263	17366	20994	24847	28399	32121	36025	40119	44587	44587							
ESCALATION $																	0	0	0	0	0	0	0
MANAGEMENT RESERVE $																	0	1076	1190	1319	1223	926	9980
CONTINGENCY $																	0	10104	14297	16469	15406	11208	96327
	TOTAL	PLAN														44587	64690	142664	191245	216353	202905	153529	1414378
CARRYOVER $																	64690	142664	191245	216353	202905	153529	
BUDGET AUTHORITY $																44587	64690	142664	191245	216353	202905	153529	

Remarks: "Budget At Completion" reflects cost and schedule baseline for: 1) All assessment ADSs; 2) ER program management ADS's; 3) ER miscellaneous ADS's; 4) remediation ADS's starting before 1 OCT 93. ADS 2106 is included in ADS 2107. ADS 2220 is included in ADS 1100. In prior FY's ADS transfers were 1107 & 1109 to 1106, 1125 & 1126 to 1122, 1152 & 1153 to 1148, and 1145 to 1144.

Reviewed by:

ENVIRONMENTAL RESTORATION PROJECT OFFICE
MILESTONE REPORT

STATUS AS OF SEPTEMBER 1992

WBS #	OU/MILESTONE	BAC	PLAN		ESTIMATE		ACTUAL	
		X $1000	START	STOP	START	STOP	START	STOP
1. 1. 3.	2107: ASSESSMENT MANAGEMENT ACTIVITIES							
	MANAGEMENT FY-92 THRU FY-02	121377	10/2/89	10/2/02		10/2/02	10/2/89	
	FY-92 PROGRAM MANAGEMENT			9/30/92				9/30/92
	FY-93 PROGRAM MANAGEMENT			9/30/93		9/30/93		
	FY-94 PROGRAM MANAGEMENT			9/30/94		9/30/94		
	FY-95 PROGRAM MANAGEMENT			9/30/95		9/29/95		
	FY-96 PROGRAM MANAGEMENT			9/30/96		9/30/96		
	FY-97 PROGRAM MANAGEMENT			9/30/97		9/30/97		
	FY-98 PROGRAM MANAGEMENT			9/30/98		9/30/98		
	MANAGEMENT INFO SYSTEMS FY-92 THRU FY-02	32117	10/2/89	10/2/02		10/2/02	10/2/89	
1. 1. 2.	2105: PROGRAMMATIC TECHNICAL SUPPORT							
	ANALYTICAL CHEMISTRY/INST DEVELOPMENT	32800	10/1/90	10/1/02		10/1/02	10/1/90	
	REMEDIATION TECHNICAL DEVELOPMENT	12873	10/1/90	9/30/98		9/30/98	10/1/90	
	ENVIRONMENTAL ENGINEERING PILOT STUDIES	15594	10/1/90	10/1/02		10/1/02	10/1/90	
	FIMAD	52570	10/1/90	10/1/02		10/1/02	10/1/90	
	RECORDS MANAGEMENT (RPF)	19602	10/1/90	10/1/02		10/1/02	10/1/90	
	DECISION/COST BENEFIT ANALYSIS	14970	10/1/90	10/1/02		10/1/02	10/1/90	
	RISK ASSESSMENT	3689	10/1/90	10/1/02		10/1/02	10/1/90	
	SAMPLE FACILITY	35451	10/1/90	10/1/02		10/1/02	10/1/90	
	DRILLING SUPPORT TEAM	7413	10/1/90	9/30/99		9/30/99	10/1/90	
	GEOCHEMICAL SUPPORT STUDY	4504	10/1/90	10/1/02		10/1/02	10/1/90	
	GEOLOGY SUPPORT TEAM	4332	10/1/90	10/1/02		10/1/02	10/1/90	
	HYDROLOGY SUPPORT TEAM	3366	10/1/90	10/1/02		10/1/02	10/1/90	
	QA/SELF ASSESSMENT	11569	10/1/90	10/1/02		10/1/02	10/1/90	
	FRAMEWORK STUDIES	4751	10/1/90	9/30/96		9/30/96	10/1/90	
	ECOLOGICAL BASELINE STUDIES	3640	10/1/90	10/1/02		10/1/02	10/1/90	
	IWP UPDATE	5164	1/2/92	2/20/03		2/20/03	1/2/92	
	32M095 IWP FOR FY-93			11/19/92		11/19/92		
	32M100 IWP FOR FY-94			11/18/93		11/18/93		
	32M105 IWP FOR FY-95			11/18/94		11/18/94		
	32M110 IWP FOR FY-96			11/20/95		11/20/95		
	32M115 IWP FOR FY-97			11/19/96		11/19/96		
	32M120 IWP FOR FY-98			11/19/97		11/19/97		
	SOP REVISIONS	462	10/1/90	9/30/98		9/30/98	10/1/90	
	DATA QUALITY OBJECTIVES AND STATISTICS	1474	10/1/90	9/30/92			10/1/90	9/30/92
	SPACE TAX	626	10/1/90	9/30/92			10/1/90	9/30/92
	SAMPLING STRATEGIES	407	10/1/90	9/30/92			10/1/90	9/30/92
	VCA - PROGRAMMATIC FUNDING	3446	10/1/92	9/30/98	10/1/92	9/30/98		
					DE-AUTHORIZATION JUNE 9 1992			
1. 1. 5.	2110: ENVIRONMENTAL ANALYTICAL CHEMISTRY FACILITY							
	ADS MANAGEMENT	89	11/1/90	9/20/95		9/28/95	11/1/90	
	ENGINEERING	2475	11/1/90	12/15/94		12/28/94	11/1/90	
	SAFETY ANALYSIS	122	11/1/90	9/30/92		10/1/93	11/1/90	
1. 5. 1.	1049: CANYONS ASSESSMENT							
	RFI WORK PLAN	6625	10/2/89	10/4/96		10/4/96	10/2/89	
	01M010 EPA/NMED DRAFT RFI WP			7/5/96		7/5/96		
	RFI	100612	8/19/96	10/29/99		4/5/00		
	01M090 EPA/NMED DRAFT RFI PH1 REPORT			1/21/99		1/21/99		
	RFI REPORT	8254	8/19/96	7/5/01	8/19/96	7/5/01		
	01M035 EPA/NMED DRAFT RFI REPORT			3/7/01		3/7/01		
	CMS PLAN	767	10/2/00	1/16/02	10/2/00	1/16/02		
	01M050 EPA/NMED DRAFT CMS PLAN			9/18/01		9/18/01		
	CMS WORK	11216	12/8/00	12/4/01	12/8/00	12/4/01		

ENVIRONMENTAL RESTORATION PROJECT OFFICE
MILESTONE REPORT

STATUS AS OF SEPTEMBER 1992

WBS #	OU/MILESTONE	BAC	PLAN		ESTIMATE		ACTUAL	
		X $1000	START	STOP	START	STOP	START	STOP
	CMS REPORT	2896	12/8/00	9/30/02	12/8/00	12/5/02		
	01M070 EPA/NMED DRAFT CMS REPORT			3/11/02		3/11/02		
	ADS MANAGEMENT	2028	10/2/89	9/30/02		9/30/02	10/2/89	
	VCA	0	10/1/91	9/30/02		9/30/02	10/1/91	
1. 5. 2.	1062: INTERIM REMEDIAL MEASURES							
	CONDUCT INTERIM REMEDIAL MEASURES FY-92	1982		COMPL		COMPL	10/1/89	3/31/92
1. 5. 3.	1066: NEPA DOCUMENTATION							
	DOE EIS DECISION			2/28/92		10/16/92		
	WASTE CHARACTERIZATION	172	4/23/92	2/11/93		2/11/93	4/23/92	
	DOE SELECT EIS CONTRACTOR			7/7/92		6/11/93		
	DRAFT EIS	2636	11/1/90	9/2/94		12/19/94	5/1/90	
	FINISH DRAFT EIS			9/2/94		12/19/94		
	FINAL EIS	1164	8/1/94	12/29/94	8/1/94	12/29/94		
	FINISH FINAL EIS			12/29/94		2/14/96		
	TECHNICAL SUPPORT DOCUMENT	537	10/30/94	2/14/95	10/30/94	2/14/95		
	COMPLETE TECHNICAL SUPPORT DOCUMENT			2/14/95		2/13/95		
1. 5. 4.	1071: TA-0, 19, 26, 73, 74 ASSESSMENT							
	RFI WORK PLAN	1645	10/19/90	6/16/92		12/18/92	10/19/90	
	06M000 EPA/NMED DRAFT RFI WORK PLAN			5/22/92				5/22/92
	RFI	45316	9/8/92	4/18/97		4/29/97	5/18/92	
	06M070 EPA/NMED DRAFT PH1 RPT/WP MOD			9/26/95		10/5/95		
	RFI REPORT	2130	4/30/93	4/6/99	4/30/93	4/15/99		
	06M025 EPA/NMED DRAFT RFI REPORT			12/2/98		12/11/98		
	CMS PLAN	83	12/3/98	10/13/99	12/14/98	12/7/99		
	06M040 EPA/NMED DRAFT CMS PLAN			6/21/99		6/30/99		
	CMS WORK	1612	10/14/99	10/5/00	10/25/99	10/17/00		
	CMS REPORT	413	10/14/99	4/30/01	4/16/99	5/9/01		
	06M060 EPA/NMED DRAFT CMS REPORT			1/12/01		1/24/01		
	ADS MANAGEMENT	1356	10/19/90	4/17/00		4/17/00	10/19/90	
	VCA	637	10/1/92	9/24/98	10/1/92	9/24/98		
1. 5. 5.	1078: TA-1 ASSESSMENT							
	RFI WORK PLAN	1274	2/1/90	8/6/92		12/3/92	2/1/90	
	07M005 EPA/NMED DRAFT RFI WORK PLAN			5/22/92				5/22/92
	RFI	10388	7/10/92	10/27/95		10/27/95	6/1/92	
	07M085 EPA/NMED DRAFT PH1 RPT/WP MOD			7/20/94		7/21/94		
	RFI REPORT	1949	10/1/92	2/2/98	10/1/92	2/2/98		
	07M030 EPA/NMED DRAFT RFI REPORT			10/9/97		10/9/97		
	CMS PLAN	90	10/10/97	8/24/98	10/10/97	8/24/98		
	07M045 EPA/NMED DRAFT CMS PLAN			5/1/98		5/1/98		
	CMS WORK	1887	10/6/98	9/29/99	10/6/98	9/29/99		
	CMS REPORT	413	8/25/98	4/21/00	8/25/98	4/21/00		
	07M065 EPA/NMED DRAFT CMS REPORT			1/6/00		1/6/00		
	ADS MANAGEMENT	1559	2/1/90	4/27/99		4/27/99	2/1/90	
	VCA	563	10/1/91	9/30/98		9/30/98	10/1/91	
1. 5. 6.	1079: TA-10, 31, 32, 45 ASSESSMENT							
	RFI WORK PLAN	2196	4/2/90	9/24/92		12/30/92	4/2/90	
	08M005 EPA/NMED RFI WORK PLAN			5/23/92				5/22/92
	RFI	13730	2/3/92	6/14/95		6/14/95	5/1/92	
	08M105 EPA/NMED DRAFT PH1 RPT/WP MOD			4/26/93		4/26/93		
	08M110 EPA/NMED DRAFT PH2 RPT/WP MOD			10/22/93		10/22/93		

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WBS #	OU/MILESTONE	BAC	PLAN		ESTIMATE		ACTUAL	
		X $1000	START	STOP	START	STOP	START	STOP
	RFI REPORT	1142	2/23/93	9/24/97	3/8/94	9/24/97		
	08M045 EPA/NMED DRAFT RFI REPORT			5/27/97		5/27/97		
	CMS PLAN	42	5/28/97	6/19/98	5/28/97	6/19/98		
	08M060 EPA/NMED DRAFT CMS PLAN			2/20/98		2/20/98		
	CMS WORK	1056	6/22/98	6/15/99	6/22/98	6/15/99		
	CMS REPORT	229	9/25/97	1/6/00	9/25/97	1/6/00		
	08M080 EPA/NMED DRAFT CMS REPORT			9/15/99		9/15/99		
	ADS MANAGEMENT	1636	4/2/90	9/30/99		9/30/99	4/2/90	
	VCA	834	10/1/92	9/30/98	10/1/92	9/30/98		
1. 5. 7.	1082: TA-11,13,16,24,25,28,37 ASSESSMENT							
	RFI WORK PLAN	3156	10/1/91	5/3/94		5/3/94	10/1/91	
	09M010 EPA/NMED DRAFT RFI WORK PLAN			3/24/93		3/24/93		
	RFI	87102	7/9/93	11/5/99	7/9/93	11/5/99		
	09M090 EPA/NMED DRAFT PH1 RPT/WP MOD			2/13/97		2/13/97		
	RFI REPORT	12523	9/27/93	2/15/01	9/27/93	2/15/01		
	09M030 EPA/NMED DRAFT RFI REPORT			11/7/00		11/7/00		
	CMS PLAN	370	11/8/00	11/7/01	11/8/00	11/7/01		
	09M045 EPA/NMED DRAFT CMS PLAN			5/4/01		5/4/01		
	CMS WORK	8992	8/8/01	4/16/02	8/8/01	4/16/02		
	CMS REPORT	2388	8/8/01	9/13/02	8/8/01	9/13/02		
	09M065 EPA/NMED DRAFT CMS REPORT			6/19/02		6/19/02		
	ADS MANAGEMENT	1745	10/1/91	9/13/02		9/13/02	10/1/91	
	VCA	1374	10/1/91	3/16/01		3/16/01	10/1/91	
1. 5. 8.	1085: TA-12,14,67 ASSESSMENT							
	RFI WORK PLAN	745	10/1/92	10/13/94	10/1/92	11/3/94		
	10M010 EPA/NMED DRAFT RFI WORK PLAN			6/28/94		6/28/94		
	RFI	13797	8/31/94	4/22/97	11/4/94	4/22/97		
	10M090 EPA/NMED DRAFT PH1 RPT/WP MOD			3/1/96		3/1/96		
	RFI REPORT	1013	12/7/94	3/11/99	12/7/94	3/11/99		
	10M035 EPA/NMED DRAFT RFI REPORT			11/3/98		11/3/98		
	CMS PLAN	53	11/4/98	10/28/99	11/4/98	10/28/99		
	10M050 EPA/NMED DRAFT CMS PLAN			5/25/99		5/25/99		
	CMS WORK	829	9/17/99	9/11/00	9/17/99	9/11/00		
	CMS REPORT	200	9/17/99	3/19/01	9/17/99	3/19/01		
	10M070 EPA/NMED DRAFT CMS REPORT			11/28/00		11/28/00		
	ADS MANAGEMENT	1675	10/1/92	3/13/01	10/1/92	3/13/01		
	VCA	115	10/1/92	9/30/98	10/1/92	9/30/98		
1. 5. 9.	1086: TA-15 ASSESSMENT							
	RFI WORK PLAN	1458	10/1/91	9/30/93		9/30/93	10/1/91	
	11M010 EPA/NMED FT RFI WORK PLAN			5/23/93		5/19/93		
	RFI	28927	4/12/93	6/24/97	4/12/93	6/13/97		
	11M030 EPA/NMED DRAFT PH1 RPT/WP MOD			8/18/95		8/9/95		
	RFI REPORT	2475	12/2/93	5/14/99	11/22/93	5/5/93		
	11M040 EPA/NMED DRAFT RFI REPORT			1/14/99		1/5/99		
	CMS PLAN	77	1/15/99	1/10/00	1/6/99	12/29/99		
	11M060 EPA/NMED DRAFT CMS PLAN			7/30/99		7/21/99		
	CMS WORK	1815	11/24/99	11/16/00	11/15/99	11/6/00		
	CMS REPORT	522	11/24/99	6/8/01	11/15/99	5/30/01		
	11M085 EPA/NMED DRAFT CMS REPORT			2/23/01		2/13/01		
	ADS MANAGEMENT	1888	10/1/91	9/29/00		9/29/00	10/1/91	
	VCA	261	10/1/91	3/1/01		3/1/01	10/1/91	

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		X $1000	START	STOP	START	STOP	START	STOP
1. 5.10.	1093: TA-18, 27, 65 ASSESSMENT							
	RFI WORK PLAN	956	10/1/91	9/15/93		9/22/93	10/1/91	
	12M020 EPA/NMED DRAFT RFI WORK PLAN			5/23/93		5/17/93		
	RFI	15043	9/16/93	3/4/96	9/23/93	3/11/96		
	12M105 EPA/NMED DRAFT PH1 RPT/WP MOD			1/10/95		1/18/95		
	RFI REPORT	1412	10/14/93	1/20/98	10/21/93	1/27/98		
	12M040 EPA/NMED DRAFT RFI REPORT			9/12/97		9/19/97		
	CMS PLAN	43	9/15/97	9/8/98	9/22/97	9/15/98		
	12M055 EPA/NMED DRAFT CMS PLAN			4/6/98		4/13/98		
	CMS WORK	1098	7/29/98	7/22/99	8/5/98	7/29/99		
	CMS REPORT	288	1/21/98	2/14/00	1/28/98	2/22/00		
	12M075 EPA/NMED DRAFT CMS REPORT			10/22/99		10/29/99		
	ADS MANAGEMENT	1483	10/1/91	2/8/00		2/8/00	10/1/91	
	VCA	217	10/1/91	2/16/00		2/16/00	10/1/91	
1. 5.11.	1098: TA-2, 41 ASSESSMENT							
	RFI WORK PLAN	909	10/1/91	9/30/93		9/30/93	10/1/91	
	13M010 EPA/NMED DRAFT RFI WORK PLAN			5/23/93		4/8/93		
	RFI	3405	10/1/92	8/28/96	10/1/92	8/19/96		
	13M030 EPA/NMED DRAFT PH1 RPT/WP MOD			3/28/95		4/14/95		
	RFI REPORT	1391	9/2/93	5/20/98	9/22/93	6/9/98		
	13M040 EPA/NMED DRAFT RFI REPORT			2/4/98		2/24/98		
	CMS PLAN	73	2/5/98	1/29/99	2/25/98	2/18/99		
	13M060 EPA/NMED DRAFT [illegible]S PLAN			8/19/98		9/8/98		
	CMS WO[illegible]	1160	12/16/98	12/9/99	1/7/99	12/30/99		
	C[illegible] REP[illegible]RT	267	12/16/98	6/28/00	1/7/99	7/18/00		
	[illegible]M085 EPA[illegible]MED DRAFT CMS REPORT			3/15/00		4/3/00		
	ADS MANAGE[illegible]T	2001	10/1/91	2/4/00		2/4/00	10/1/91	
	VCA	217	10/1/91	2/11/00		2/11/00	10/1/91	
2.	1100: TA-20 ASSESSMENT							
	RFI WORK [illegible]LAN	1462	10/1/92	11/8/94	10/1/92	10/19/94		
	14M010 EPA/NMED DRAFT RFI WORK PLAN			5/23/94		7/5/94		
	RFI	11984	11/9/94	7/25/97	9/7/94	7/13/99		
	14M090 EPA/NMED DRAFT PH1 RPT/WP MOD			5/1/96		5/1/96		
	RFI REPORT	1522	12/12/94	7/13/99	12/13/94	7/13/99		
	14M035 EPA/NMED DRAFT RFI REPORT			3/15/99		3/15/99		
	CMS PLAN	73	3/16/99	3/8/00	3/16/99	3/8/00		
	14M050 EPA/NMED DRAFT CMS PLAN			9/27/99		9/27/99		
	CMS WORK	1563	1/27/00	1/19/01	1/27/00	1/19/01		
	CMS REPORT	392	7/14/99	8/6/01	7/14/99	8/6/01		
	14M070 EPA/NMED DRAFT CMS REPORT			4/20/01		4/20/01		
	ADS MANAGEMENT	1715	10/1/92	3/29/01	10/1/92	3/29/01		
	VCA	265	10/1/92	8/6/01	10/1/92	8/6/01		
1. 5.13.	1106: TA-21 ASSESSMENT							
	RFI WORK PLAN	2112		COMPL		COMPL	10/2/89	9/30/91
	RFI	38433	10/1/91	9/30/99		9/30/99	10/1/91	
	15M004 EPA/NMED DRAFT PH1 RPT/WP MOD			10/8/96		10/8/96		
	RFI REPORT	3457	9/28/95	2/19/99	9/28/95	2/19/99		
	15M010 EPA/NMED DRAFT RFI REPORT			10/14/98		10/15/98		
	CMS PLAN	124	8/6/98	7/30/99	8/6/98	7/30/99		
	15M020 EPA/NMED DRAFT CMS PLAN			2/25/99		2/25/99		
	CMS WORK	2984	6/18/99	6/12/00	6/18/99	6/12/00		
	CMS REPORT	854	6/13/00	7/30/01	6/13/00	7/30/01		

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		X $1000	START	STOP	START	STOP	START	STOP
				11/8/00		11/8/00		
	15M045 EPA/NMED DRAFT CMS REPORT	4766	10/2/89	9/30/02		9/30/02	10/2/89	
	ADS MANAGEMENT	265	10/1/91	9/28/01		9/28/01	10/1/91	
	VCA							
1. 5.14.	1111: TA-6, 7, 22, 40, 58, 62 ASSESSMENT	5400	10/1/90	9/30/98		9/30/98	10/1/90	
	RFI WORK PLAN			5/23/93		4/7/93		
	16M010 EPA/NMED DRAFT RFI WORK PLAN	14730	10/4/93	8/11/97	10/4/93	8/11/97		
	RFI			11/3/95		11/3/95		
	16M095 EPA/NMED DRAFT PH1 RPT/WP MOD	1813	1/7/94	7/1/99	1/7/94	7/1/99		
	RFI REPORT			3/4/99		3/4/99		
	16M035 EPA/NMED DRAFT RFI REPORT	65	3/5/99	2/28/00	3/5/99	1/28/00		
	CMS PLAN			9/16/99		9/16/99		
	16M050 EPA/NMED DRAFT CMS PLAN	1560	1/25/00	1/17/01	1/25/00	11/16/01		
	CMS WORK	390	6/4/99	11/16/01	6/4/99	11/16/01		
	CMS REPORT			8/1/01		8/1/01		
	16M070 EPA/NMED DRAFT CMS REPORT	1569	10/1/90	9/28/01		9/28/01	10/1/90	
	ADS MANAGEMENT	235	10/1/91	10/31/00		10/31/00	10/1/91	
	VCA							
1. 5.15.	1114: TA-3 30, 59, 60, 61, 64 ASSESSMENT	2909	10/1/91	6/24/94		6/24/94	10/1/91	
	RF AN			5/18/93		5/18/93		
	PA/NMED DRAFT RFI WORK PLAN	28557	6/24/94	12/22/97	6/24/94	12/22/97		
	R			2/19/97		2/19/97		
	10 EPA/NMED DRA 1 RPT/WP MOD	10165	10/3/94	12/8/99	10/3/94	12/8/99		
	RFI REPORT			8/5/99		8/5/99		
	17M050 EPA/N DRAFT RFI REPORT	488	8/6/99	7/31/00	8/6/99	7/31/00		
	CMS PLAN			2/28/00		2/28/00		
	17M065 EPA/NMED DRAFT CMS PLAN	7486	2/29/00	2/15/01	2/29/00	2/15/01		
	CMS WORK	1894	2/29/00	8/31/01	2/29/00	8/31/01		
	CMS REPORT			5/17/01		5/17/01		
	17M085 EPA/NMED DRAFT CMS REPORT	1575	10/1/91	9/28/01		9/28/01	10/1/91	
	ADS MANAGEMENT	1237	10/1/91	9/30/98		9/30/98	10/1/91	
	VCA							
1. 5.16.	1122: TA-33 ASSESSMENT	1813	4/2/90	5/21/93		5/21/93	4/2/90	
	RFI WORK PLAN			5/21/92				5/22/92
	18M005 EPA/NMED DRAFT RFI WORK PLAN	23649	7/1/93	10/4/96	7/1/93	10/4/96		
	RFI			3/22/95		3/22/95		
	18M085 EPA/NMED DRAFT PH1 RPT/WP MOD	2053	7/1/93	10/6/98	7/1/93	10/6/98		
	RFI REPORT			6/8/98		6/8/98		
	18M025 EPA/NMED DRAFT RFI REPORT	72	6/9/98	6/2/99	6/9/98	6/2/99		
	CMS PLAN			1/5/99		1/5/99		
	18M040 EPA/NMED DRAFT CMS PLAN	1603	4/29/99	4/21/00	4/29/99	4/21/00		
	CMS WORK	413	10/7/98	11/7/00	4/29/99	11/7/00		
	CMS REPORT			7/24/00		7/24/00		
	18M060 EPA/NMED DRAFT CMS REPORT	1606	4/2/90	9/30/99		9/30/99	4/2/90	
	ADS MANAGEMENT	235	10/1/91	11/7/00		11/7/00	10/1/91	
	VCA							
1. 5.17.	1129: TA-4, 5, 35, 42, 48, 52, 55, 63, 66 ASSESSMENT	1771	11/1/90	5/3/93		5/3/93	11/1/90	
	RFI WORK PLAN			5/29/92				5/22/92
	20M100 EPA/NMED DRAFT RFI WORK PLAN	26621	6/7/93	12/4/96		12/4/96		
	RFI			7/31/95		7/31/95		
	20M180 EPA/NMED DRAFT PH1 REPORT	5727	6/7/93	12/12/97	6/7/93	12/12/97		
	RFI REPORT							

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		X $1000	START	STOP	START	STOP	START	STOP
	20M125 EPA/NMED DRAFT OF RFI REPORT			9/8/97		9/8/97		
	CMS PLAN	271	9/9/97	9/1/98	9/9/97	9/1/98		
	20M140 EPA/NMED DRAFT CMS PLAN			5/8/98		5/8/98		
	CMS WORK	4154	8/12/98	4/6/99	8/12/98	4/6/99		
	CMS REPORT	1040	8/12/98	9/30/99	12/15/97	9/30/99		
	20M160 EPA/NMED DRAFT CMS REPORT			6/30/99		6/30/99		
	ADS MANAGEMENT	1433	11/1/90	9/30/99		9/30/99	11/1/90	
	VCA	714	10/1/91	2/10/99		2/10/99	10/1/91	
1. 5.18.	1130: TA-36, 68, 71 ASSESSMENT							
	RFI WORK PLAN	543	10/1/91	4/27/93		5/26/93	10/1/91	
	21M015 EPA/NMED DRAFT RFI WORK PLAN			5/22/93		3/24/93		
	RFI	2626	4/26/93	9/21/95	5/26/93	9/22/95		
	21M095 EPA/NMED DRAFT PH1 RPT/WP MOD			7/26/94		7/27/94		
	RFI REPORT	638	10/1/92	8/19/97	10/1/92	8/20/97		
	21M040 EPA/NMED DRAFT RFI REPORT			4/21/97		4/22/97		
	CMS PLAN	38	4/22/97	4/21/98	4/22/97	4/22/98		
	21M055 EPA/NMED DRAFT CMS PLAN			11/4/97		11/5/97		
	CMS WORK	514	3/12/98	3/11/99	3/13/98	3/12/99		
	CMS REPORT	119	8/20/97	9/24/99	8/21/97	9/27/99		
	21M075 EPA/NMED DRAFT CMS REPORT			6/10/99		6/11/99		
	ADS MANAGEMENT	1489	10/1/91	9/30/99		9/30/99	10/1/91	
	VCA	83	10/1/91	9/30/98		9/30/98	10/1/91	
1. 5.19.	1132: TA-[illegible] ASSESSMENT							
	RFI WORK PLAN	1105	10/1/91	10/28/93		10/28/93	10/1/91	
	22M01[illegible] EPA/N[illegible] DRAFT RFI WORK PLAN			6/8/93		3/24/93		
	RFI	78074	9/9/93	4/12/99	6/24/93	3/2/99		
	22M090 EPA/NMED DRAFT PH1 RPT/WP MOD			11/13/96		10/1/96		
	RFI REPORT	968	12/14/93	4/19/00	10/29/93	3/9/00		
	22M035 EPA/NMED DRAFT RFI REPORT			1/13/00		11/30/99		
	CMS PLAN	43	1/14/00	11/27/00	12/1/99	10/12/00		
	22M050 EP[illegible] CMS PLA			8/1/00		6/20/00		
	CMS WORK	[illegible]	11/28/00	4/2/01	10/13/00	2/20/01		
	CMS REPORT	[illegible]	4/20/00	9/28/01	10/13/00	8/17/01		
	22M070 EPA/NMED DRAFT CMS REPORT			6/14/01		5/3/01		
	ADS MANAGEMENT	1939	10/1/91	9/28/01		9/28/01	10/1/91	
	VCA	97	12/14/93	4/10/95	12/14/93	4/10/95		
1. 5.20.	1136: TA-46 ASSESSMENT							
	RFI WORK PLAN	214	10/1/92	10/4/94	10/1/92	9/13/94		
	24M010 EPA/NMED DRAFT RFI WORK PLAN			5/23/94		5/27/94		
	RFI	806	10/1/93	4/23/97	10/1/93	4/23/97		
	24M095 EPA/NMED DRAFT PH1 RPT/WP MOD			1/31/96		1/31/96		
	RFI REPORT	190	11/3/94	3/12/99	11/3/94	3/12/99		
	24M035 EPA/NMED DRAFT RFI REPORT			11/4/98		11/4/98		
	CMS PLAN	6	11/5/98	9/28/00	11/5/98	9/28/00		
	24M050 EPA/NMED DRAFT CMS PLAN			5/26/99		5/26/99		
	CMS WORK	174	9/20/99	9/28/00	9/20/99	9/28/00		
	CMS REPORT	46	3/15/99	8/6/01	3/15/99	8/6/01		
	24M070 EPA/NMED DRAFT CMS REPORT			4/20/01		4/20/01		
	ADS MANAGEMENT	2849	10/1/92	8/27/01	10/1/92	8/27/01		
	VCA	24	10/2/95	9/30/98	10/2/95	9/30/98		

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		X $1000	START	STOP	START	STOP	START	STOP
1. 5.21.	1140: TA-46 ASSESSMENT							
	RFI WORK PLAN	1267	10/1/91	2/15/94		2/16/94	10/2/91	
	25M010 EPA/NMED DRAFT RFI WORK PLAN			5/23/93		8/18/93		
	RFI	6467	8/31/93	3/1/96	8/19/93	1/27/98		
	25M090 EPA/NMED DRAFT PH1 RPT/WP MOD			1/4/95		12/29/94		
	RFI REPORT	1579	9/30/93	1/29/98	9/29/93	1/27/98		
	25M035 EPA/NMED DRAFT RFI REPORT			9/17/97		9/17/97		
	CMS PLAN	58	9/19/97	9/14/98	9/18/97	9/11/98		
	25M050 EPA/NMED DRAFT CMS PLAN			4/15/98		4/15/98		
	CMS WORK	1261	8/10/98	8/6/99	8/7/98	8/2/99		
	CMS REPORT	294	1/30/98	3/6/00	1/28/98	3/6/00		
	25M070 EPA/NMED DRAFT CMS REPORT			11/8/99		11/8/99		
	ADS MANAGEMENT	1515	10/1/91	3/1/00		3/1/00	10/1/91	
	VCA	186	10/1/91	3/6/00		3/6/00	10/1/91	
1. 5.22.	1144: TA-49 ASSESSMENT							
	RFI WORK PLAN	949	7/2/90	11/18/92		12/1/92	7/2/90	
	26M010 EPA/NMED DRAFT RFI WORK PLAN			5/22/92				5/22/92
	RFI	4050	9/14/92	9/30/99		2/22/01	5/22/92	
	26M030 EPA/NMED DRAFT PH1 RPT MOD			6/13/95		4/20/95		
	RFI REPORT	831	7/1/97	1/29/01	5/8/97	12/1/00		
	26M040 EPA/NMED DRAFT RFI REPORT			9/21/00		7/31/00		
	CMS PLAN	31	9/22/00	9/28/01	8	9/28/01		
	26M060 EPA/NMED DRAFT CMS PLAN			4/13/01		5/8/01		
	CMS WORK	574	8/7/01	7/31/02		6/7/02		
	CMS REPORT	1	1/30/01	2/24/03	4/00	12/30/02		
	26M085 EPA/NMED DRAFT CMS REPORT			10/31/02		11/28/02		
	ADS MANAGEMENT	1656	7/2/90	2/23/00		2/23/00	7/2/90	
	VCA	78	1/2/97	2/24/03	1/2/97	2/24/03		
1. 5.23.	1147: TA-50 ASSESSMENT							
	RFI WORK PLAN	1028	4/6/90	4/12/93		1/22/93	4/6/90	
	27M010 EPA/NMED DRAFT RFI WORK PLAN			5/18/92				5/22/92
	RFI	12518	4/13/93	12/28/95	1/8/93	11/11/97		
	27M090 EPA/NMED DRAFT PH1 RPT/WP MOD			10/31/94		10/31/94		
	RFI REPORT	867	8/12/93	11/11/97		11/11/97		
	27M035 EPA/NMED DRAFT RFI REPORT			7/11/97		7/11/97		
	CMS PLAN	48	7/14/97	3/14/00	7/14/97	3/14/00		
	27M050 EPA/NMED DRAFT CMS PLAN			2/2/98		2/2/98		
	CMS WORK	671	5/27/98	5/19/99	5/27/98	5/19/99		
	CMS REPORT	151	11/12/97	2/29/00	11/12/97	2/29/00		
	27M070 EPA/NMED DRAFT CMS REPORT			8/3/99		8/3/99		
	ADS MANAGEMENT	1840	4/6/90	9/28/00		9/28/00	4/6/90	
	VCA	102	1/2/97	3/14/00	1/2/97	3/14/00		
1. 5.24.	1148: TA-51, 54 ASSESSMENT							
	RFI WORK PLAN	2670	10/2/89	9/24/92		1/11/93	10/2/89	
	28M015 EPA/NMED DRAFT RFI WORK PLAN			5/14/92				5/22/92
	RFI	46588	10/1/91	8/19/98		11/13/98	10/1/91	
	28M095 EPA/NMED DRAFT PH1 RPT/WP MOD			8/28/96		8/28/96		
	RFI REPORT	2036	7/15/93	10/30/00	7/15/93	10/30/00		
	28M040 EPA/NMED DRAFT RFI REPORT			6/29/00		6/29/00		
	CMS PLAN	90	7/7/99	5/23/00	5/7/99	10/30/00		
	28M055 EPA/NMED DRAFT CMS PLAN			2/1/00		2/1/00		

ENVIRONMENTAL RESTORATION PROJECT OFFICE
MILESTONE REPORT

STATUS AS OF SEPTEMBER 1992

WBS #	OU/MILESTONE	BAC	PLAN		ESTIMATE		ACTUAL	
		X $1000	START	STOP	START	STOP	START	STOP
	CMS WORK	1413	5/24/00	3/15/01	5/24/00	3/15/01		
	CMS REPORT	357	5/24/00	9/28/01	5/24/00	9/28/01		
	28M075 EPA/NMED DRAFT CMS REPORT			6/14/01		6/14/01		
	ADS MANAGEMENT	2144	10/2/89	9/28/01		9/28/01	10/2/89	
	VCA	3346	10/1/91	9/29/00	10/1/92	9/29/00		
	MDA G PILOT STUDIES	0	10/1/91	9/30/98		9/30/98	10/1/91	
1. 5.25.	1154: TA-57 FENTON HILL ASSESSMENT							
	RFI WORK PLAN	257	10/1/92	9/22/94	10/1/92	9/23/94		
	30M010 EPA/NMED DRAFT RFI WORK PLAN			5/17/94		5/18/94		
	RFI	684	9/23/94	7/3/97	9/26/94	7/3/97		
	30M090 EPA/NMED DRAFT PH1 RPT/WP MOD			1/19/96		1/19/96		
	RFI REPORT	201	10/24/94	1/28/99	10/25/94	1/28/99		
	30M035 EPA/NMED DRAFT RFI REPORT			9/22/98		9/22/98		
	CMS PLAN	21	9/23/98	9/16/99	9/23/98	9/16/99		
	30M050 EPA/NMED DRAFT CMS [illegible]N			4/14/99		4/14/99		
	CMS WORK	217	8/6/99	7/31/00	8/6/99	7/31/00		
	CMS REPORT	57	1/29/99	2/5/01	1/29/99	2/5/01		
	30M070 EPA/NMED DRAFT CMS REPORT			10/13/00		10/13/00		
	ADS MANAGEMENT	1398	10/1/92	9/28/01	10/1/92	9/28/01		
	VCA	33	10/1/92	9/28/01	10/1/92	9/28/01		
1. 5.26.	1157: TA-8, 9, 23, 69 ASSESSMENT							
	RFI WORK PLAN	1264	12/1/91	10/13/93		9/7/93	12/2/91	
	31M015 EPA/NMED DRAFT RFI WORK PLAN			5/23/93		6/10/93		
	RFI	12713	10/14/93	2/26/96	10/14/93	1/26/98		
	31M095 EPA/NMED DRAFT PH1 RPT/WP MOD			1/3/95		1/12/95		
	RFI REPORT	2555	10/1/93	1/15/98	10/12/93	1/26/98		
	31M040 EPA/NMED DRAFT RFI REPORT			9/9/97		9/18/97		
	CMS PLAN	95	9/10/97	9/30/98	9/19/97	1/25/00		
	31M055 EPA/NMED [illegible]AFT CMS PLAN			4/1/98		4/10/98		
	CMS WORK	2239	7/24/98	9/30/99	8/4/98	8/3/99		
	CMS REPORT	474	1/16/98	4/6/00	1/27/98	2/8/00		
	31M075 EPA/NMED DRAFT CMS REPORT			12/17/99		10/18/99		
	ADS MANAGEMENT	1489	12/1/91	9/29/00		9/29/00	12/2/91	
	VCA	337	12/1/91	9/30/98		9/30/98	12/2/91	
1. 6. 1.	1063: INTERIM REMEDIAL MEASURES REMEDIATION							
	CONDUCT INTERIM REM MEASURES REM FY-92	1346	10/2/89	9/30/92			10/2/89	9/30/92
1. 6. 2.	1067: RCRA MIXED WASTE STORAGE/DISPOSAL FACILITY							
	SITE SELECTION			COMPL		COMPL		10/1/91
	MWSDF SITE CHARACTERIZATION	818	4/1/92	10/28/94		10/28/94	5/15/92	
	MWSDF ENGINEERING	5487	10/1/91	3/3/95		3/3/95	10/1/91	
	ENGINEERING STUDY REPORT			2/28/92		10/30/92		
	MWSDF DESIGN CRITERIA DOCUMENT			8/4/92		10/30/92		
	TITLE I DESIGN			7/27/93		7/27/93		
	TITLE II DESIGN - RECEIVE RCRA PERMIT			3/20/95		3/20/95		
	MWSDF PROCUREMENT	5047	5/19/93	12/20/95	5/19/93	12/20/95		
	MWSDF PERFORMANCE ASSESSMENT	142	9/1/92	3/17/93	10/1/92	3/17/93		
	MWSDF CONSTRUCTION	6389	11/29/93	9/25/96	11/29/93	9/25/96		
	FACILITY CONSTRUCTION			10/16/96		10/16/96		
	MWSDF WASTE ISSUES	561	10/1/91	6/9/94		6/9/94	10/1/91	
	MWSDF SAFETY ANALYSIS	628	9/1/92	9/24/96	1[illegible]/4/93	9/24/96		

ENVIRONMENTAL RESTORATION PROJECT OFFICE
MILESTONE REPORT

STATUS AS OF SEPTEMBER 1992

WBS #	OU/MILESTONE	BAC	PLAN		ESTIMATE		ACTUAL	
		X $1000	START	STOP	START	STOP	START	STOP
	MWSDF REGULATORY ISSUES	373	3/11/94	4/11/95	3/11/94	4/11/95		
	MWSDF MANAGEMENT	905	6/26/90	10/23/96		10/23/96	6/26/90	
	STARTUP OPERATION OF MWSDF			9/26/96		9/26/96		
1. 6.12.	1135: TA DETONATION SITE CLOSURE REMEDIATION							
	CLOSURE EMENTAT	356	11/1/90	8/3/92		12/9/92	11/1/90	
	23M005 OSURE IMPL MENTATION CMPL			8/3/92		12/9/92		
	CLOSURE CERTIFICATION AND REPORT	189	8/4/92	2/1/93	10/13/92	1/25/93		
	23M015 CLOSURE CERTIFICATION RPT			1/22/93		1/25/93		
	ADS MANAGEMENT	130	11/1/90	9/30/93		9/30/93	11/1/90	

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Glossary

This glossary is included in this version of the Installation Work Plan (IWP) as a draft. Updated, more complete versions will appear in future editions of the IWP.

ER PROGRAM GLOSSARY
DRAFT

Accuracy Any measure of the bias of a sampling and measurement procedure. Accuracy may be quantified using the difference between the average measurement and the correct measurement. **(Campbell)**

Action description memorandum
Action level
Activity data sheet
Administrative procedure

Administrative record A file established in compliance with the requirements set forth in Section 113(k) of CERCLA, as amended, consisting of information upon which EPA bases its decision on the selection of response actions. The administrative record should be established at or near the facility at issue and made available to the public. **(DOE 1991)**

Adsorption Bonding, frequently ionic, of a substance to soil or other medium. A substance is said to be adsorbed if the concentration in the boundary region of a soil particle is greater than in the interior of the contiguous phase. **(DOE 1991)**

Aliquot A subsample removed from a sample (grab or composite) for analysis. **(Campbell)**

Alluvial fan A fan-shaped accumulation of sediment deposited by a stream. (1122)

Alluvium Clay, silt, sand, gravel, or other rock materials transported by flowing water and deposited in fairly recent geologic time as sorted or semisorted sediments in riverbeds, estuaries, flood plains, lakes shores, and fans at the base of mountain slopes. **(CDR)**

Alpha radiation Ionizing radiation composed of alpha particles emitted in the radioactive decay of certain nuclides. Alpha particles consist of two protons and two neutrons bound together; an alpha particle is identical to the nucleus of a helium atom. It is the least penetrating of the three common types of radiation—alpha, beta, gamma—and can be blocked by a sheet of paper or outer dead layer of skin. **(CDR; DOE 1991)**

Andesite A gray, fine-grained volcanic rock, chiefly plagioclase and pyroxene. (1122)

Applicable, relevant, or appropriate requirement (ARARs) Those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. **(40 CFR 300.5)**

A requirement under other environmental laws (other than CERCLA) may be either "applicable" or relevant and appropriate," but not both. Identification of ARARs must be done on a site-specific basis and involves a two-part analysis: first a determination of whether a given requirement is applicable; then, if it is not applicable, a determination of whether it is nevertheless both relevant and appropriate. **(DOE 1991)**

Those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA

site, or that address problems or situation sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. **(DOE 1991)**

Aquifer An underground geological form on, group of formations, or part of a formation that is capable of yielding a significant amount of water to a well or spring. **[40 CFR 1.1.12(l)]**

An underground rock formation composed of materials such as sand, soil, or gravel that can store and supply ground water to wells and springs. Most aquifers used in the United States are within a thousand feet of the earth's surface. **(DOE 1991)**

Area of concern

Army Corps of Engineers A branch of the US Department of Defense that has specialized equipment and personnel for maintaining navigation channels, for removing navigation obstruction, for accomplishing structural repairs, and for performing maintenance to hydropower electric generating equipment. The Corps can also provide design services, perform construction, and provide contract writing and contract administrative services for other federal agencies, such as EPA for Superfund actions. **(DOE 1991)**

As low as practicable

As low as reasonably achievable (ALARA) An approach to radiation protection to control or manage exposures (both individual and collective to the work force and general public) as lows as social, technical, economic, practical, and public policy considerations permit. As used in this order, ALARA is not a dose limit but a process, which has the objective of dose levels as far below applicable limits of the order as reasonably achievable. (DOE **Order 5480.11)**

An approach to radiation protection to control or manage exposures (both individual and collective to the work force and the general public) and releases of radioactive material to the environment as low as social, technical, economic, practical, and public policy considerations permit. As used in this order, ALARA is not a dose limit but rather it is a process that has as its objective the attainment of dose levels as far below the applicable limits of the order as practicable. **(DOE Order 5400.5) from (DOE 1991)**

Ash flow tuff A tuff deposited by a hot dense current, ash-flow tuff can be either welded or unwelded and often fills in channels, making the thickness of the resulting deposit a function of the underlying topography. (CDR)

Atomic Energy Commission

Background levels The distribution of concentrations of naturally occurring or widely distributed constituents in environmental media. (Campbell)

Background radiation The radioactivity in the environment, including cosmic rays from space and radiation that exists elsewhere—in the air, in the earth, and in man-made materials. In the US, most people receive 100 to 250 millirems of background radiation per year. **(DOE 1991)**

Barrier Any material or structure that prevents or substantially delays movement of water or radionuclides. (10 CFR 60.2)

Basalt A hard, dense, dark volcanic rock composed chiefly of plagioclase, augite, olivine, and magnetite. **(1122)**

Base/neutral/acid

Baseline risk assessment A risk assessment conducted using an appropriate, site-specific exposure scenario but assuming no mitigating or corrective measures beyond those already in place. **(Campbell)**

Bedrock Solid rock that underlies all soil, sand, clay, gravel, and loose material on the earth's surface. **(CDR)**

Bentonite A clay containing the mineral montmorillonite, and variable amounts of magnesium and iron, that formed over time by the alteration of volcanic ash. Bentonite can adsorb large quantities of water and expand to several times its normal volume. **(CDR)**

Bermed area

Beta radiation Emitted from a nucleus during fission. Beta radiation can be stopped by an inch of wood or a thin sheet of aluminum. **(DOE 1991)**

Bias A systematic discrepancy between the actual and correct results of a sampling and analysis procedure. Bias may result from imperfect procedures for sampling (e.g., use of judgment samples), for measurement (e.g., errors in instrument calibration), or both. **(Campbell)**

Biological resource evaluation team

Boneyard

Bound

Breccia **Rock** consisting of sharp, angular fragments cemented together or embedded in a fine-grained matrix. **(CDR)**

Buffer zone A portion of the disposal site that is controlled by the licensee and that lies under the disposal units and between the disposal units and the boundary of the site. (10 CFR 61.2)

Byproduct material (a) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident or to the process of producing or utilizing special nuclear material. For purposes of determining the applicability of the Resource Conservation and Recovery Act to any radioactive waste, the term "any radioactive material" refers only to the actual radionuclides dispersed or suspended in the waste substance. The nonradioactive hazardous waste component of the waste substance will be subject to regulation under the Resource Conservation and Recovery Act.

(b) The tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction operations and which remain underground do not constitute "byproduct material."

Caldera A volcanic collapse structure, generally on the order of tens of kilometers in diameter, formed during the eruption of volumetrically large (tens to hundreds of cubic kilometers of dense rock equivalent), ashflow and ash-fall tuff deposits. **(CDR)**

Caliche Gravel, sand, or desert debris cemented by porous calcium carbonate; also the calcium carbonate cement. **(CDR)**

Cambrian The oldest of the periods of the Paleozoic Era, which lasted from 570 to 500 million years ago. **(CDR)**

Chain of custody

Change control
Change order

Characterization Describes the qualities or peculiarities of something; defining (1122)

Cinder cone A conical hill formed by the accumulation of cinders and other matter ejected from a volcano. (1122)

Cleanup Actions undertaken during a removal or remedial response to physically remove or treat a hazardous substance that poses a threat or potential threat to human health and welfare and the environment and/or real and personal property. Sites are considered cleaned up when EPA removal or remedial programs have no further expectation or intention of returning to the site and threats have been mitigated or do not require further action. (DOE 1991)

Cleanup levels Media-specific target concentration levels for constituents that must be met by any corrective action selected. Cleanup levels are established during corrective measures studies (CMS) using selection-of-remedy criteria such as protection of human health and the environment; compliance with regulatory requirements; reduction of toxicity, mobility, or volume through treatment; long- and short-term effectiveness; implementability; cost; and public acceptance.

Clinoptilolite A zeolite mineral. **(1122)**

Closure

CMS risk assessment A risk assessment conducted using an appropriate, site-specific exposure scenario to estimate risk reduction following the implementation of corrective measures. **(Campbell)**

Cobble A rock fragment larger than a pebble and smaller than a boulder. **(1122)**

Colluvium Rock debris accumulated at the base of a cliff or slope, brought there principally by gravity. **(1122)**

Community relations EPA's program to inform and encourage public participation in the Superfund process and to respond to community concerns. The term "public" includes citizens directly affected by the site, other interested citizens or parties, organized groups, elected officials, and potentially responsible parties.

Community relations plan A plan that is prepared at the start of most Superfund response activities to direct activities that will allow the community affected by the site to be kept informed of EPA, state and potentially responsible party activities. Those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, or that address problems or situation sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. **(DOE 1991)**

Community relations program plan The facility-wide community relations plan developed by the Environmental Restoration Program at Los Alamos National Laboratory and described in the Installation Work Plan **(Barnett)**

Community relations project plan A project-specific community relations plan developed for individual operable units at Los Alamos National Laboratory and described in operable unit work plans. **(Barnett)**

Comparability The relationship between measurements produced by different sampling and analysis procedures, or by the same sampling and analysis procedures applied under different conditions, for the same target population. There are no generally applicable measures of comparability. **(Campbell)**

Completeness Any measure of relationship between the quantity and/or quality of measurements produced by a specified sampling and analysis procedure and the quantity and/or quality needed, planned or anticipated prior to implementation of the procedure. **(Campbell)**

Composite liquid waste sampler

Composite sample A specimen that is formed by combining and homogenizing several grab samples. **(Campbell)**

Comprehensive Environmental Assessment and Response Program

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. **(40 CFR 300.5)**

A federal law passed in 1980 and modified in 1986 by SARA. The acts created a special tax that goes into a trust fund, commonly known as Superfund, to investigate and clean up abandoned or uncontrolled hazardous waste sites. Under the program, EPA can either

(1) pay for site cleanup when parties responsible for the contamination cannot be located or are unwilling or unable to per form the work, or

(2) take legal action to force parties responsible for site contamination to clean up the site or pay back the federal government for the cost of the cleanup. **(DOE 1991)**

Conceptual exposure model A conceptual model whose objects are qualitative or quantitative descriptions of sources of contamination, environmental transport pathways for contamination, and biota that may be impacted by contamination (called receptors) and whose relationships describe qualitatively or quantitatively the release of contamination from the sources, the movement of contamination along the pathways to the exposure points, and the uptake of contaminants by the receptors. (Campbell)

Conceptual hydrological (or hydrogeological) model

Conceptual model A mathematical model that represents, by means of symbolic objects and qualitative or quantitative relationships among them, a physical, biological, or social system. (Campbell)

Confidence interval

Conglomerate Rock consisting of pebbles and gravel embedded in a loosely cementing material **(1122)**

Constituent Any compound or element present in environmental media, including both naturally occurring and anthropogenic elements. (Campbell)

Construction project manager

Contaminant Any constituent present in environmental media or on structural debris at a concentration above its screening action level. **(Campbell)**

Contaminant of concern Any constituent present in environmental media or on structural debris at a concentration above its screening action level. **(Campbell)**

Contamination reduction zone

Controlled area Any area to which access is controlled in order to protect individuals from exposure to radiation and radioactive materials.

Control zone
Controlled distribution
Corrective action
Corrective action management unit

Corrective measures study The portion of a RCRA corrective action that is generally equivalent to a feasibility study taken under Superfund. **(DOE 1991)**

Corrective measures implementation

Curie A unit of radioactivity defined as the amount of a radioactive material that has an activity of 3.7 x 10^{10} disintegrations per second. **(CDR)**

Dacite A fine-grained extrusive rock containing plagioclase, quartz, alkali feldspar, pyroxene, hornblende, and biotite **(1122)**

Data quality objectives (DQOs) Qualitative and quantitative statements that are developed before sampling begins to allow EPA to identify the quality of data that must be collected during Superfund actions. **(DOE 1991)**

Specifications for sampling and analysis plans, including but not limited to specifications of the media and areas to be sampled, sampling protocols to be used, variables to be measured, analytical methods to be used, and precision and accuracy requirements for the sampling and analysis procedures. **(Campbell)**

Data quality objectives process A step-by-step procedure to develop appropriate data quality objectives based on a decision model (that is, on a statement of decision alternatives, uncertainties, and values). **(Campbell)**

Decay **(1)** The process whereby radioactive materials undergo a change from one nuclide, element, or state to another, releasing radiation in the process. this action ultimately results in a decrease in the number of radioactive nuclei present in the sample. (2) The spontaneous transformation of one nuclide into a different nuclide or into a different isotope of the same nuclide. **(CDR)**

Decision analysis

Decision model A conceptual model whose objects are qualitative or quantitative descriptions of options (decision alternatives), knowledge (and uncertainties), and objectives (or values) with respect to a given problem. **(Campbell)**

Decommissioning The permanent removal from service of surface facilities and components necessary for preclosure activities only, after ~~repository~~ **facility** closure, in accordance with regulatory requirements and environmental policies. **(CDR)**

Decontamination The removal of unwanted material (especially radioactive material) from the surface of or from within another material. **(CDR)**

Deferred action Postponement of selection and implementation of corrective measures until a future date, usually following decommissioning of an active site. **(Campbell)**

Deferred investigation Postponement of complete evaluation of a PRS, which may be proposed when investigation would have negative impacts on current Laboratory operations when it is determined than the site presents no current risk to human health or the environment. **(Campbell)**

Deficiency

Department of Energy
Department of Energy acquisition regulation
Derived air concentration

Design-based (probability) sampling A theory of statistical sampling according to which estimation of population parameters should be based on the probability of obtaining the selected sample. Randomization of the sampling plan is essential for the validity of inference based on this approach. **(Campbell)**

Detection level The minimum concentration of a substance that can be measured with a 99% confidence that the analytical concentration is greater than zero. **(DOE 1991)**

Detection limit

Discharge As defined by Section 311 (a)(2) of the Clean Water Act, includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting, emptying, or dumping of oil, but excludes discharges in compliance with a permit under Section 402 of the act, discharges resulting from circumstances identified and reviewed and made part of the public record with respect to a permit issued or modified under Section 402 of the Act and subject to a condition in such permit, or continuous or anticipated intermittent discharges from a point source, identified in a permit or permit application under Section 402 of the act, that are caused by events occurring within the scope of relevant operating or treatment systems. For purposes of the NCP (National Contingency Plan?), discharge also means threat of discharge. **(DOE 1991)**

Discomfort curve Quantification of decision maker's tolerance for making the wrong decision, as a function of the amount by which the true condition of the site is above or below the action level. If the truth is very close to action levels, larger probabilities of error are acceptable than when the truth is much worse than, or much better than, those action levels. There is also a difference between tolerance for Type I and Type II errors. **(1122)**

A function that quantifies a decision maker's values that associates with each possible state of a population parameter (or with a functions of the state such as the associated risk under a specified exposure scenario) an upper bound for the probability of selecting a nonoptimal decision alternative, given that that state is the true one. **(Campbell)**

Disposal Emplacement of waste in a manner that assures isolation from the biosphere for the foreseeable future with no intent of retrieval and that requires deliberate action to regain access to the waste. **(DOE Order 5820.2A)**

The discharge, deposit, injection, dumping, spilling, leaking, or placing of any solid waste or hazardous waste into or on any land or water so that such solid waste or hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground waters. **(RCRA 1004(3)**

Distribution [(probability) distribution] A function defined on subsets of a set S whose values are real numbers between zero and one, with the properties that its value on the empty set is zero, its value on S is one, and its value on the union of disjoint subsets is the some of its values on each set. **(Campbell)**

Diurnal Having daily cycles. **(CDR)**

DOE environmental checklist
Domain

Dose The quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body. **(CDR)**

Dose equivalent **An estimate of the** amount of biological damage done by the deposition in tissue of a given unit of absorbed radiation does. The does equivalent is obtained by multiplying the absorbed radiation dose by a qualifying factor. The unit of does equivalent is the rem. **(CDR)**

Drop tower
Dry well
Duplicate
Emergency response planning guideline
Energy Research and Development Administration
Energy Systems Acquisition Advisory Board

Environmental assessment (EA)

Environmental medium Any medium capable of absorbing or transporting constituents released from a PRS, including tuffs, soils and sediments derived from these tuffs, surface water, groundwater, air, structural surfaces, and debris. **(Campbell)**

Environmental impact statement
Environmental Protection Agency

Eolian Pertaining to the wind, especially said of sediment deposition by the wind, of structures such as wind-formed ripple marks, or of erosion accomplished by the wind. **(CDR)**

Ephemeral stream

Escarpment A long, more or less continuous cliff or relatively steep slope that was produced by erosion or faulting and faces in one general direction, breaking the continuity of the land by separating two levels or gently sloping surfaces. **(CDR)**

Estimate The value of an estimator based on the observed sample. **(Campbell)**

Estimator (statistic) Any function of a sample probability distribution, such as the sample maximum. (Campbell)

Evapotranspiration Discharge of water from the earth's surface to the atmosphere by evaporation from lakes, streams, and soil surfaces, and by transpiration from plants **(1122)**

Exclusion zone
Executive order

Expected value (mean) of a real random variable The first moment of the probability distribution of a real random variable; symbolically,

$$\int_{x \in S}^{?} x\, dP(x).$$ **(Campbell)**

Facility for Information Management, Analysis, and Display

Fanglomerate A sedimentary rock, originally deposited in an alluvial fan and subsequently cemented into a firm rock **(1122)**

Fault A fracture or zone of fractures along which there has been displacement of the sides relative to one another parallel to the fracture. **(CDR)**

Feasibility study A study undertaken by the lead agency to develop and evaluate options for remedial action. The FS emphasizes data analysis and is generally performed concurrently and in an interactive fashion with the remedial investigation (RI), using data gathered during the RI. The RI data re used to define the objectives of the response action, to develop remedial action alternatives, and to undertaken an initial screening and detailed analysis of the alternatives. The term also refers to a report that describes the results of the study. (40 CFR 300.5)

A study undertaken by the lead agency go develop and evaluate options for remedial action. the feasibility study emphasizes data analysis, implementablity of alternatives, and cost analyses, as well as compliance with mandates to protect human health and the environment and attain regulatory standards of other laws. The FS is generally performed concurrently and in an interactive fashion with the RI, using data gathered during the RI. **(DOE 1991)**

Federal acquisition regulation
Field instrument for detection of low-energy radiation
Field sampling plan
Field task leader
Field team

Field team leader Person responsible for implementing the sampling plan the OU's specific QAPjP. **(Wagner memo, EM-13:91-836)**

Field duplicate A second specimen collected as near as possible to one already included in the sample. In channel sediment sampling, field duplicates come from the same sediment catchment as another specimen. **(1122)**

Final safety analysis report (FSAR)
Finding
Firing site
Five-year plan
Flame ionization detector

Flood plain That portion of a river valley that is built of sediments deposited during the present regimen of the stream and is covered with water when the river overflows its banks at flood stages. **(CDR)**

Formerly Utilized Sites Remedial Action Program
Framework studies

Gamma radiation A form of electromagnetic, high-energy radiation emitted from a nucleus. Gamma rays are essentially the same as x-rays and require heavy shieldings, such as concrete or steel, to be stopped.

Gas chromatograph
Geographic Information System

Groundwater Water in a saturated zone or stratum beneath the surface of land or water. **[CERCLA 101(12)]**

Geohydrology
Glove box
Glow discharge mass spectrometry

Grab sample A specimen collected by a single application of a field sampling procedure to a target population, e.g., the surface soil from a single hole collected following the SOP for spade and scoop sampling, or a single air filter left in the field for three months. **(Campbell)**

Graphite furnace atomic absorption
Ground fault circuit interrupter

Half-life The time required for one-half of radioactive atoms initially present in a sample to decay. Each radionuclide has a characteristic half-life ranging from a fraction of a second to thousands of years. **(CDR, DOE 1991)**

Hazard-ranking system The method used by EPA to evaluate the relative potential of hazardous substance releases to cause health or safety problems or ecological or environmental damage. **(40 CFR 300.5)**

A scoring system used to evaluate potential relative risks to public health and the environment from releases or threatened releases of hazardous substances. EPA and states use the HRS to calculate a site score, from 0 to 100, based on the actual or potential release of hazardous substances from a site through air, surface water, or ground water to affect people. This score is the primary factor used to decide if a hazardous waste site should be placed on the National Priorities List. **(DOE 1991)**

Hazardous and Solid Waste Amendments (HSWA) Amendments to the Resource Conservation and Recovery Act that Congress passed in 1984. HSWA added the land disposal restrictions, minimum technology requirements, and expanded corrective action authorities to the RCRA statute. **(DOE 1991)**

Hazardous substance The term "hazardous substance" means (A) any substance designated pursuant to Section 311(b)(2)(A) of the Federal Water Pollution Control Act, (B) any element, compound, mixture, solution, or substance designated pursuant to Section 102 of this act, (c) any hazardous waste having the characteristics identified under or listed pursuant to Section 3001 of the Solid Waste Disposal Act (but not including any waste the regulation of which under the SWDA has been suspended by an act of Congress, (D) any toxic pollutant listed under Section 307(a) of the FWPCA, (E) any hazardous air pollutant listed under Section 112 of the Clean Water Act, and (F) any imminently hazardous chemical substance or mixture with respect to which the Administrator has taken action pursuant to Section of the Toxic Substances Control Act. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under Subparagraphs A through F of this paragraph, and the term does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas). **[CERCLA 101(14)]**

Hazardous Waste A solid waste, or combination of solid waste, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (1) cause, or significantly contribute to,

an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness; or (2) pose a substantial present or potential hazard to human health or the environment when improperly treat stored, transported, or disposed of, or otherwise managed.

Health and safety program plan
Health and safety project leader
Health and safety project plan

Health physics The branch of science concerned with the biological effects of radiation exposure. **(CDR)**

High-efficiency air particulate (filter) /n air filter capable of removing from an air stream at least 99.97% of particulate material as small as 0.3 micron in diameter. **(CDR)**

High-pressure ionization chamber
High-pressure liquid chromatography

Holocene An epoch of the Quaternary Period from the end of the Pleistocene to the present. **(CDR)**

Hornblende A silicate mineral containing magnesium, iron, calcium, sodium, and aluminum **(1122)**

Hydraulic conductivity The volume of water that will move through a medium in a unit of time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow. **(CDR)**

Hydraulic gradient A change in the static pressure of groundwater, expressed in terms of the height of water above a datum, per unit of distance in a given direction. **(CDR)**

Hydrogeology
Immediately dangerous to life and health
Inductively coupled plasma atomic emission spectroscopy
Inductively coupled plasma emission spectroscopy
Inductively coupled plasma mass spectroscopy
Indurated Hardened. **(1122)**

Industrial hygienist Responsible for monitoring industrial hygiene conditions affecting the health and safety of site workers **(Wagner**

Infiltration Water flow into the soil at ground surface. **(CDR)**

Inflow Water movement into a reference location. **(CDR)**

Initiator A nuclear weapons component **(1122)**

Injection well
Installation work plan
Installation work plan

Institutional controls Controls prohibiting or limiting access to contaminated media; may consist of deed restrictions, use restrictions, permitting requirements, etc. **(DOE 1991)**

Institutional interim remedial measures
Instrumental neutron activation analysis
Interim action
Interim remedial measure

Interim remedial measure

Intermittent stream

Intertonguing Interfingering. (1122)

Joint A surface of a fracture or parting in a rock, without displacement. **(CDR)**

Judgment sample A sample selected on the basis of professional judgment or convenience. **(Campbell)**

Land disposal restriction A RCRA program that restricts land disposal of RCRA hazardous wastes and requires treatment to promulgated treatment standards. These restrictions may be an important ARAR for Superfund actions. (DOE 1991)

Laser-induced breakdown spectroscopy

Latite An extrusive volcanic rock containing plagioclase and alkali feldspars, pyroxene, and/or hornblende **(1122)**

Leachate A contaminated liquid resulting when water percolates or trickles through waste materials and collects components of those wastes. Leaching may occur at landfills and may result in hazardous substances entering soil, surface water, or groundwater. **(DOE 1991)**

Leaching The dissolution of soluble constituents of a solid material by the natural action of percolating water or chemicals. **(CDR)**

Level of concern
Limit of quantification

Lithology The study of rocks. Also the description of a rock on the basis of such characteristics as structure, color, mineral composition, grain size, and arrangement of its component parts. **(CDR)**

Los Alamos Site Characterization Program
Lower exposure limit
Major system acquisition
Management Information System
Manhattan Engineer District

Man-rem A unit used in health physics to compare the effects of different amounts of radiation on groups of people. It is obtained by multiplying the average does equivalent to the whole body or a given organ or tissue (measured in rems) by the number of persons in the selected population. **(CDR)**

Mass spectrometer
Material disposal area

Matrix Relatively fine material in which coarser fragments or crystals are embedded; also called "ground mass." **(CDR)**

Maximum contaminant level Under the Safe Drinking Water Act, the maximum permissible level of a contaminant in water that is delivered to any user of a public water system that serves 15 or more connections and 25 or more people. The standards set as MCs take into account the feasibility and cost of attaining the standard. **(DOE 1991)**

Maximum permissible level

Measure A scale or transformation mapping the states of a variable into real numbers or vectors, in a way which preserves the natural ordering, if any, of the states. **(Campbell)**

Measurement, analysis The result of applying an appropriate measure to the observed states of a target population parameter. **(Campbell)**

Measurement error A discrepancy between a measurement and the true state of the population parameter for the observed sample. Measurement error arises, even in the absence of measurement bias, from imperfect application of the selected measure to the sample. **(Campbell)**

Memorandum of agreement

Memorandum of understanding A statement agreed to by two or more parties that recognizes the interrelationship of their functions and specifies appropriate interactions between or among the parties. **(DOE 1991)**

Migration The movement of oil, gas, or water (including that containing radionuclides) through porous and permeable rock. **(CDR)**

Migration pathway Route (e.g., a stream or river) for potential movement of contaminants to environmental receptors (plants, animals, humans)**(1122)**

Minimum detection limit

Mississippian The fifth of seven periods (320 to 345 million years ago) in which the Paleozoic is divided in the United States. **(CDR)**

Mitigation (1) Avoiding an impact altogether by not taking a certain action or parts of an action. (2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation. (3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment. (4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action. (5) Compensating for the impact by replacing or providing substitute resources or environments. **(CDR)**

Model A mathematical or physical system, obeying certain specified conditions, whose behavior is used to understand a physical, biological, or social system to which it is analogous in some way. **(McGraw-Hill Dictionary of Scientific and Technical Terms)**

Model-based (prediction approach to) sampling A theory of statistical sampling according to which estimation of population parameters should be based on a model for the population, whose formulation may depend on theory, data, or both. Randomization of the sampling plan is not essential for the validity of inference base on this approach, but it is still desirable because it protects the investigator against modeling errors. **(Campbell)**

Model parameter Any *real or vector variable* that characterizes a system being modeled. Examples of parameters used in *conceptual exposure modeling* are rates of release of contamination to the environment, numbers of workers at a site. **(Campbell)**

Mixed activation product
Mixed fission products

Mixed waste
Mixed-oxide semiconductor
Mixed-Waste Storage and Disposal Facility
Model

Monitoring wells Special wells drilled at specific locations on or off a hazardous waste site where groundwater can be sampled at selected depths and studied to determine such things as the direction in which groundwater flows and the types and amounts of contaminants present. (DOE 1991)

Monthly report
Mortar impact area
Multichannel analyzer
Multiple-energy gamma assay spectrometer

National ambient air quality standards (NAAQS) Standards established under the Clean Air Act that regulate the ambient air quality for six priority pollutants. These standards may be ARARs for Superfund sites. **(DOE 1991)**

National Contingency Plan (found in 40 CFR 300)

National Committee on Radiation Protection

National emission standards for hazardous air pollutants (NESHAPS) Standards set under the Clean Air Act that regulate the release of hazardous substances from specific sources. These standards may be ARARs for Superfund sites.

National Environmental Policy Act
National Environmental Research Park

National Pollutant Discharge Elimination System

National Priorities List (NPL) EPA's list of the most serious uncontrolled or abandoned hazardous waste sites identified for possible long-term remedial response using money from the Trust Fund. The list is based primarily on the score a site receives on the Hazard Ranking System. EPA is required to update the NPL at least once a year. **(DOE 1991)**

National wetlands inventory

Neighbor A second specimen collected nearer to another sampling location than the average distance between samples. In channel sediment sampling, a neighbor would be collected from a different sediment catchment than the first specimen. **(1122)**

New Mexico Environmental Division (NMED)

No further action (NFA) One of the possible end points of the corrective action process: a decision that no further investigation or remediation is warranted for a PRS. No further action may be proposed during the RCRA field investigation (RFI) of a PRS if it is determined that no release with potentially significant risk to human health or the environment has occurred. (Campbell)

Notice of deficiency

Nuclear Criticality Safety Committee

Nuclear Regulatory Commission

Null hypothesis Default hypothesis, which will be accepted unless sufficiently conclusive evidence that it is false is obtained **(1122)**

Numerical model A conceptual model, some of whose objects and/or relationships are quantified by algebraic or arithmetic expressions. (Campbell)

Occupational exposure limit
Occupational Safety and Health Administration
Off-gas

Office of Emergency and Remedial Response **Under the** supervision of a director, this office is responsible to the assistant administrator (of EPA) for the emergency and remedial response functions of the Office of Solid Waste and Emergency Response (OSWER). The director is responsible for developing national strategy, programs, technical policies, regulations, and guidelines for the control of abandoned hazardous waste sites and response to and prevention of oil and hazardous substance spills. **(DOE 1991)**

Office of Enforcement and Compliance Monitoring Coordinates (EPA's) civil and criminal enforcement actions with the Department of Justice and provides Superfund enforcement support through the activities of the National Enforcement Investigation Center (NEIC) The NEIC performs special environmental monitoring work, evidence audit control processes to ensure proper chain-of-custody procedures, cleanup of federal facility sites, and nonbinding preliminary allocations of responsibility. **(DOE 1991)**

Office of Solid Waste As part of EPA's Office of Solid Waste and Emergency Response, this office is responsible for managing and implementing the RCRA program. **(DOE 1991)**

Office of Solid Waste and Emergency Response (OSWER) Provides policy, guidance, and direction for EPA's hazardous waste and emergency response programs. The functions of these programs include the development and enforcement of policies, standards and regulations for solid and hazardous waste treatment, storage, and disposal; national management of Superfund; and the development of guidelines for the Emergency Preparedness, "Community Right-to-Know," and Underground Storage Tank programs. **(DOE 1991)**

Office of Waste Programs Enforcement As part of the Office of Solid Waste and Emergency Response, this office provides enforcement policy and support for the Superfund and RCRA programs. **(DOE 1991)**

On-scene control group

Operable unit A discrete action that composes an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration or eliminates or mitigates a release, threat of release, or pathway of exposure. the cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site. **(DOE 1991)**

Operable unit project leader (OUPL) The person responsible for RCRA investigations at the operable unit to which he/she has been assigned. **(Wagner memo, EM-13:91-836)**

Organic vapor analyzer

Outfall

Paleozoic The era of geologic time between the Precambrian and Mesozoic eras that consists of the Cambrian, Ordovician, Silurian, Devonian, Carboniferous (Mississippian ;and Pennsylvanian), and Permian periods (about 570 million to 225 million years ago).

Perched groundwater Unconfined groundwater in a zone of saturation separated from an underlying saturated zone by an unsaturated zone. Perched groundwater is supported by a perching bed whose permeability is so low that water percolating downward through it is not able to bring water in the underlying unsaturated zone above atmospheric pressure. **(CDR)**

Paleogroundwater Ancient groundwater **(1122)**

Percentile of a probability distribution p is a 100 ath percentile of a probability distribution if p/100 is an ath quantile. **(Campbell)**

Percolation The passage of a liquid through a porous substance; e.g., the movement of water, under hydrostatic pressure developed naturally underground, through the interstices and pores of the rock or soil; i.e., the slow seepage of water through soils or porous deposits. **(CDR)**

Permissible exposure limit
Personal protective equipment
Phase I sampling
Phase II sampling
Phase report
Phenocryst A relatively large, conspicuous crystal in a porphyritic rock **(1122)**
Photoionization detector
Pilot study

Plutonium A heavy, radioactive, man-made metallic element. Its most important isotope is fissionable ^{236}Pu, which is produced by the irradiation of ^{236}U. Routine analysis cannot distinguish between the ^{239}Pu and ^{240}Pu isotopes, hence the term $^{239,240}Pu$.

Pollutant Includes, but is not limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring; except that the terms "pollutant or contaminant" shall not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under Subparagraphs (A) through (F) of Paragraph (14) and shall not include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas).

Population A set of entities or a continuum in a physical, biological or social system, e.g., the residents of Los Alamos County, or the water in an alluvial aquifer, or the plants in Pajarito Canyon. **(Campbell)**

Population dose The sum of the radiation dose received by the individual members of a population exposed to a particular source of event. It is expressed in units of man-rem. **(CDR)**

Population parameter Any variable that characterizes a population. Examples are number of Los Alamos residents under age 20, tritium concentrations in an alluvial aquifer, or the set of species found in Pajarito Canyon. **(Campbell)**

Population [probability] distribution The distribution of a population parameter. **(Campbell)**

Population mean, variance, quantiles, etc. The mean, variance, quantiles, etc. of a population distribution. **(Campbell)**

Porosity The ratio of the total volume of interstices in rock or soil to its total volume expressed as a percentage or as a fraction.

Porphyritic Said of the texture of an igneous rock in which larger crystals (phenocrysts) are set in a finer ground mass **(1122)**

Potential release site
Potential contact medium

Practical quantitation limit

Precambrian The geologic time that elapsed before the beginning of the Paleozoic era (the Paleozoic began about 570 million years ago). **(CDR)**

Precision Reproducibility of measurements produced by a specified sampling and analysis procedure. Irreproducibility may be the result of both sampling error and measurement error. Precision may be quantified using the standard deviation of a probability distribution describing the measurements, a range, or similar indicators of dispersion. **(Campbell)**

Preliminary assessment The process of collecting and reviewing available information about a known or suspected hazardous waste site or release. The extent of release and degree of threat to human health and the environment are evaluated to determine whether further study is needed and whether the release meets the criteria for a CERCLA-funded removal. **(DOE 1991)**

Preliminary safety analysis report
Principal investigator
Program management plan
Program manager (ER Program)
Programmatic environmental impact statement
Programmatic project leader
Project leader
Project management plan
Project team

Proportional sample A stratified sample in which each subpopulation in a partition of the total population is represented by a number of samples that is proportional to the fraction of the total population that belongs to that subpopulation. (Note: A set is partitioned by a collection of its subsets if each member of the set belongs to one and only one of the subsets.) (Campbell)

Quality assurance (QA) All the planned and systematic actions necessary to provide adequate confidence that a structure, system, or component is constructed to plans and specifications and will perform satisfactorily. **(CDR)**

Quality assurance/quality control (QA/QC) A system of procedures, checks, audits, and corrective actions used to ensure that field work and laboratory analysis during the investigation and cleanup of Superfund sites meet established standards. **(DOE 1991)**

Quality assurance management staff (EPA)
Quality assurance program plan

Quality assurance project plan A written document associated with all remedial site sampling activities, which presents in specific terms the organization (where applicable), objectives, functional activities, and specific quality assurance (QA) and quality control (QC) activities designed to achieve the data quality objectives of a specific project(s) or continuing operation(s). The QAPP is prepared for each specific project or continuing operation (or group of similar projects of continuing operations). The QAPjP will be prepared by the responsible program office, regional office, laboratory, contractor, recipient of an assistance agreement, or other organization. For an enforcement action, potentially responsible parties may prepare a QAPjP subject to lead agency approval. **(40 CFR 300.5)**

Quality procedure

Quantile of a probability distribution The *ath* quantile of the probability distribution for a real random variable *x* is any real number *q* such that the probability that *x* is less than *q* equals *a*. **(Campbell)**

Quaternary The second period of the Cenozoic era, following the Tertiary, and the corresponding system of rocks. **(CDR)**

Radiation Refers to the process of emitting energy in the form of rays or particles that are thrown off by disintegrating atoms. The rays or particles emitted may consist of alpha, beta, or gamma radiation. (DOE 1991)

Radon A colorless, odorless, naturally occurring, radioactive gaseous element formed by radioactive decay of radium atoms. The chemical symbol is Rn, atomic weight is 222, and the half-life is 3.82 days. **(DOE 1991)**

Radiation protection technician Person responsible for monitoring radiation levels during field investigations. **(Wagner memo, EM-13:91-836)**

Radionuclide of concern

Random variable Conceptual model object described by a set of feasible states together with a probability distribution defined on that set. **(Campbell)**

Randomized sample A sample whose selection makes use of a mechanism for generating random numbers (or a satisfactory analog of such a mechanism) to determine which specimens from a target population are included in a sample. **(Campbell)**

RCRA facility assessment (RFA) The first step in the RCRA corrective action process, generally equivalent to the preliminary assessment/site investigation taken under Superfund. **(DOE 1991)**

RCRA facility investigation (RFI) The second step of a RCRA corrective action, generally equivalent to the RI portion of the Superfund process. **(DOE 1991)**

Real-time aerosol monitor

Real variable A variable whose set of feasible states is a subset of the real numbers. **(Campbell)**

Receipt acknowledgment

Receptor A person, plant, animal, or geographical location that is exposed to a chemical or physical agent released to the environment by human activities **(1122)**

Recharge The process by which water is added to the zone of saturation, either directly into a geologic formation or indirectly by way of another formation or through unconsolidated sediments. **(CDR)**

Recommended exposure limit

Reconnaissance sampling Sampling contaminant concentrations in a *target population* for the purpose of bounding their *population probability distributions.* **(Campbell)**

Record
Records management program plan
Records management project plan

Record of decision A public document that explains which cleanup alternative(s) will be used at NPL sites. The record of decision is based on information and technical analysis generated during the RI/FS and consideration of public comments and community concerns. **(DOE 1991)**

Records-Processing Facility

Regulatory standard, regulatory concentration criteria Media-specific contaminant concentration levels of potential concern that are mandated in specific pieces of federal or state legislation (e.g., the Safe Drinking Water Act, New Mexico Water Quality Control Commission regulations). **(Campbell)**

Relative percent difference

Release Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant), but excludes

(A) any release which results in exposure to persons solely within a workplace, with respect to a claim which such persons may assert against the employer of such persons;

(B) emissions from the engine exhaust of a motor vehicle, rolling, stock, aircraft, vessel, or pipeline pumping station engine;

(C) release of source, byproduct, or special nuclear material from a nuclear incident, as those terms are defined in the Atomic Energy Act, if such release is subject to requirements with respect to financial protection established by the Nuclear Regulatory Commission under Section 170 of such act, or, for the purposes of Section 104 of this title or any other response action, any release of source, byproduct, or special nuclear material from any processing site designated under Section 102(a)(1) or 302(a) of the Uranium Mill Tailings Radiation Control Act of 1978, and

(D) the normal application of fertilizer. **[CERCLA 101(22)]**

Relevant and appropriate requirements Those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate. **(DOE 1991)**

Remedial design

Remedial investigation A process undertaken by the lead agency to determine the nature and extent of the problem presented by a release. The remedial investigation emphasizes data collection and site characterization, and is generally performed concurrently and in an interactive fashion with the feasibility study. The RI includes sampling and monitoring, as necessary, and includes the gathering of sufficient information to determine the necessity for remedial action and to support the evaluation of remedial alternatives. **(40 CFR 300.5)**

Remedial investigation/feasibility study (RI/FS) Investigative and analytical studies usually performed at the same time in an interactive, iterative process, and together referred to as the "RI/FS." They are intended to

- gather the data necessary to determine the type and extent of contamination at a Superfund site,
- establish criteria for cleaning up the site,
- identify and screen cleanup alternatives for remedial action, and
- analyze in detail the technology and costs of the alternatives. **(DOE 1991)**

Remedial response A long-term action that stops or substantially reduces a release or threatened release of hazardous substances that is serious but does not pose an immediate threat to public health and/or the environment. **(DOE 1991)**

Remediation

Remedy or remedial action Those actions consistent with permanent remedy taken instead of or in addition to removal actions in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment. The term includes, but is not limited to, such actions at the location of the release as storage, confinement, perimeter protection using dikes, trenches, or ditches, clay cover, neutralization, cleanup of released hazardous substances and associated contaminated materials, recycling or reuse, diversion, destruction, segregation of reactive wastes, dredging or excavations, repair or replacement of leaking containers, collection of leachate and run-off, on-site treatment or incineration, provision of alternative water supplies, and any monitoring reasonably required to assure that such actions protect the public health and welfare and the environment. The term includes the costs of permanent relocation of residents and businesses and community facilities where the President determines that, alone or in combination with other measures, such relocation is more cost-effective than and environmentally preferable to the transportation, storage, treatment, destruction, or secure disposition off site of hazardous substances, or may otherwise be necessary to protect the public health or welfare; the term includes off-site transport and off-site storage, treatment, destruction, or secure disposition of hazardous substances and associated contaminated materials. **[CERCLA 101(24)]**

Activities conducted at DOE facilities to reduce potential risks to people and/or harm to the environment from radioactive and/or hazardous substance contamination. **(DOE Order 5820.2A)**

Those actions consistent with permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances to that they do not migrate to cause substantial danger to present or future public health or welfare or the environment. **(DOE 5400.5)**

Remove or removal The cleanup or removal of released hazardous substances from the environment, such actions as may be necessary taken in the event of the threat of release of hazardous substances

into the environment, such actions as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances, the disposal of removed material, or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release. The term includes, in addition, without being limited to, security fencing or other measures to limit access, provision of alternative water supplies, temporary evacuation and housing of threatened individuals not otherwise provided for, action taken under Section 104(b) of this act, and any emergency assistance which may provided under the Disaster Relief and Emergency Assistance Act. **[CERCLA 101 (23)]**

Removal action An immediate action taken over the short term to address a release or threatened release of hazardous substances. **(DOE 1991)**

Replicate

Reportable quantity For any CERCLA hazardous substance, the quantity established in Table 302.4 and Appendix B of 40 CFR 302, the release of which requires notification unless federally permitted. **(DOE Order 5000.3A)**

~~Representative sample~~ A sample from a target population that may be considered typical of that population in one or more respects. This is an extremely ill-defined concept, and its use should be avoided. Consider using one of the following alternatives: simple random sample, stratified sample, proportional sample, systematic sample, judgmental sample, composite sample, grab sample. (Campbell)

Representativeness Similarity between the measurements produced by a specified sampling and analysis procedure and the true target population parameters. There are no generally applicable measures of representativeness. **(Campbell)**

Resin bed

Resource Conservation and Recovery Act A federal law that established a structure to track and regulate hazardous wastes from the time of generation to disposal. The law requires safe and secure procedures to be used in treating, transporting, storing, and disposing of hazardous substances. RCRA is designed to prevent new, uncontrolled hazardous waste sites. The law also regulates the disposal of solid waste that may not be considered hazardous. **(DOE 1991)**

Respond or response As defined by Section 101 (25) of CERCLA, means remove, removal, remedy, or remedial action, including enforcement activities related thereto. **(DOE 1991)**

Response action A CERCLA-authorized action at a Superfund site involving either a short-term removal action or a long-term remedial response that may include, but is not limited to, the following activities.

- Removing hazardous materials from a site to an EPA-approved, licensed hazardous waste facility for treatment, containment, or destruction.
- Containing the waste safely on site to eliminate further problems.
- Destroying or treating the waste on site using incineration or other technologies.
- Identifying and removing the source of groundwater contamination and halting further movement of the contaminants.

Restoration

Restricted Area Any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include

areas used as residential quarters, although a separate room or rooms ... a residential building may be set apart as a restricted area. **(10 CFR 60.2)**

Retardation The act or process that reduces the rate of movement of a chemical substance in a water stream relative to the average velocity of the water. The movement of the chemical substance in the water can be retarded by sorption and desorption reactions, by precipitation and dissolution reactions, and by diffusion into the pore water of the rock matrix. **(CDR)**

Rhyodacite A group of extrusive porphyritic igneous rocks intermediate in composition between dacite and rhyolite, with quartz, plagioclase, and biotite (or hornblende) as the main phenocryst minerals and a fine-grained to glassy ground mass **(1122)**

Rhyolitic Characteristic of a group of extrusive igneous rocks, generally prophyritic and exhibiting flow texture with crystals of quartz and alkali feldspar in a glassy to cryptocrystalline ground mass (rhyolite). **(CDR)**

Risk A measure of a negative or undesirable impact associated with an event. **(Campbell)**

Risk assessment A risk assessment is generated by collecting, analyzing, and synthesizing scientific data to produce the hazard identification, does response, and exposure assessment portion of the risk assessment and to characterize risk. ***(RCRA/CERCLA Update*, June 1992)**

(For the ER Program) An assessment of the potential human health or environmental risk associated with contamination of environmental media. Risk assessment includes hazard identification, exposure assessment, and dose response analysis. For human health risk assessments, two end points are generally estimated: (1) excess lifetime cancer risk and (2) noncarcinogenic toxicological impacts. **(Campbell)**

Risk assessment, baseline

A risk assessment conducted using one or more scenarios appropriate for the site but assuming no mitigating or corrective measures beyond those already in place. **(Campbell)**

Risk assessment, preliminary

A risk assessment conducted using a simplified and not necessarily appropriate scenario and assuming no mitigating or corrective measures beyond those already in place. **(Campbell)**

Risk characterization Includes disclosure of uncertainties, information on data and methodology, and numerical estimates accompanied by descriptive information. ***(RCRA/CERCLA Update*, June 1992)**

Risk management Risk management is the integration of risk characterization with other nonscientific considerations specified in applicable statutes to make and justify regulatory decisions. ***(RCRA/CERCLA Update*, June 1992)**

Safety analysis report (SAR) A document that analyzes the facility and its safety-related systems for use in establishing whether or not the facility can be operated with reasonable assurance of no undue risk to the health and safety of the public and with adequate provisions for the protection of property and the environment. **(CDR)**

Sample (a) A statistical sample is a set of specimens taken from the target population, for which various parameters of interest are measured. If the target population consists of discrete items, then a sample consists of a subset of these items. If the target population is an environmental continuum (e.g., surface soil in some well-defined region or channel sediments in a drainage), then specimens must be collected

according to a standard operating procedure which specifies how much soil is to be included in each specimen, how to collect and store it, etc.

(b) A field or laboratory sample is an individual specimen taken from a target population, or sometimes the product of a field activity such as the filter from a air monitor or a thermoluminescent dosimeter (TLD), which is submitted for laboratory analysis following a period of exposure at the site. **(1122)**

(1) A set of specimens collected from a target population, as in "a sample of size 3". (2) One of a set of specimens collected from a target population, as in "Three samples were submitted for laboratory analysis." **(Campbell)**

Sample maximum The largest measurement of a variable made for the sample. It is impossible to infer the relationship between the sample maximum and the population maximum, but the sample maximum may be used to make inferences about population percentiles below the 100th percentile. **(Campbell)**

Sample mean, variance, quantiles The mean (expected value), variance, quantiles of a sample probability distribution. **(Campbell)**

Sample [probability] distribution The probability distribution that assigns the value $1/N$ to each measurement of an outcome variable recorded for a sample of size N. **(Campbell)**

Sampling The selection of samples from a target population. **(Campbell)**

Sampling and analysis procedure A combined protocol or rule for sampling a target population and obtaining measurements of one or more population parameters for specimens in the sample. **(Campbell)**

Sampling error A discrepancy between the sample distribution and the target population distribution of a population parameter. Sampling error arises, even in the absence of bias or measurement error, from observing only a subset of the total population. **(Campbell)**

Sampling plan

Saturated zone **That part of the** earth's crust beneath the regional water table in which all voids, large and small, are ideally filled with water under pressure greater than atmospheric. (10 CFR 60.2)

Sanidine A high-temperature mineral of the alkali feldspar group. **(1122)**

Scrap detonation site

Screening action levels Media-specific concentration levels for constituents derived using conservative criteria. The derivation of SALs is most often based on low risk under a very restrictive exposure scenario, but if a regulatory standard exists and is lower than the value derived by this risk-based computation, it will be used for the screening action level **(Campbell)**

Screening assessment Evaluation of information about a PRS to determine whether hazardous or radioactive constituents are present above the levels of concern defined by media-specific SALs or regulatory standards. **(Campbell)**

Screening level

Scrubber

Secondary alteration minerals Minerals formed by processes after the original formation of the rock by chemical changes to the original minerals or by deposition along fractures **(1122)**

Seismicity The occurrence of earthquakes or the spatial distribution of earthquake activity; also the phenomenon of earth movement. **(CDR)**

Silurian The third of seven periods (395 to 430 million years ago, before the Devonian and after the Ordovician) of the Paleozoic Era. (CDR)

Simple random sample A sample that is randomized in such a manner that whether or not a given member of the target population is included in the sample is completely independent of the inclusion of any other member. (Campbell)

Site characterization The program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the procedures under this part. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings and geophysical testing needed to decide whether site characterization should be undertaken. (10 CFR 60.2)

Site safety officer

Soil gas Those gaseous elements and compounds that occur in the small spaces between particles of the earth or soil. Rock can contain gas also. Such gases can move through or leave the soil or rock, depending on changes in pressure. Radon is a gas that forms in the soil wherever radioactive decay of radium occurs.

Solid waste management unit Means any discernible unit at which solid wastes have been placed at any time, irrespective of whether the nit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released. (HSWA Module)

Split

Standard deviation of a real random variable The square root of the variance of a real random variable. (Campbell)

Standard operating procedure

State Any member of the set of feasible values for a variable. (Campbell)

Statistic A function of the sample data, such as the average of the observed values (the sample mean), or the largest observed value (the sample maximum), or the number of observations exceeding a predefined level (the number of exceedances) **(1122)**

Statistical parameter Any real or vector variable that characterizes a probability distribution. Examples are expected values and the correlation between two random variables. **(Campbell)**

Stratification Classification of the target population into two or more non-overlapping and exhaustive categories (strata) on the basis of characteristics which are known *a priori* for the entire population **(1122)**

Stratified sample Statistical sample including specimens from all strata of the target population. If the target population has spatial extent, and characteristics of interest may have important variability from one part to another, care must be taken to ensure that the sample is not concentrated in one area. If the target population has both mesa-top surface soils and soils or sediments in drainage channels, and there is reason to believe that contaminants might move through or sorb on these different types of soil in different manners, then the sample should include specimens of both types. **(1122)**

A sample including one or more specimens from each of several subpopulations of the target population. (Note: If the specimens are selected from within each subpopulation using *simple random sampling*, then the sample is called a stratified random sample.) **(Campbell)**

Stratigraphy The study of rock strata to include age relationships **(1122)**

Superfund Amendments and Reauthorization Act of 1986 In addition too certain free-standing provisions of law, it includes amendments to CERCLA, the SWDA, and the Internal Revenue Code. Among the free-standing provisions of law is Title III of SARA, also known as the "Emergency Planning and Community Right -to-Know Act of 1986" and Title IV of SARA, also known as the "Radon Gas and Indoor Air Quality Research act of 1986." Title V of SARA amending the Internal Revenue Code is also known as the "Superfund Revenue Act of 1986." **(40 CFR 300.5)**

Surveillance

Survey

SWMU aggregate

SWMU group

Systematic sample A sample selected by following a prespecified rule. (Note: A systematic sample may be randomized by selecting a random starting point for applying the rule, but the resulting will not, in general, have all of the desirable properties of a simple or stratified random sample.) (Campbell)

Target population A collection of items or an environmental region to be characterized. The target population must be explicitly defined prior to sampling so that a sample which represents important features of this population can be selected. Some target populations mentioned in Chapter 3 are: surface soils within a defined area, channel sediments within defined drainages, projectiles in berms, debris in landfills, and sludge in septic tanks. **(1122)**

A population for which the states of one or more population parameters are to be observed. **(Campbell)**

Technical team

Tertiary The earlier of the two geologic periods that make up the Cenozoic Era, extending from 65 to 1.8 million years ago.

Telephone record

Thermoluminescent dosimeter

Topography The physical features of a place or region. **(1122)**

Townsite

Toxic pollutants The 126 individual priority toxic pollutants contained in 65 toxic compounds or classes of compounds (including organic pollutants and metals) adopted by EPA pursuant to Section 307 (a) (1) of the Clean Water Act. **(DOE 1991)**

Toxic Substances Control Act

Toxicity characteristic leaching procedure

Transmissivity A measure of the amount of water that can be transmitted horizontally by the full saturated thickness of the aquifer under a hydraulic gradient of 1. **(DOE 1991)**

Transport or transportation The movement of a hazardous substance by any mode, including pipeline (as defined in the Pipeline Safety Act), and in the case of hazardous substance which has been accepted for transportation by a common or contract carrier, the term "transport" or "transportation" shall include any stoppage in transit which is temporary, incidental to the transportation movement, and at the ordinary operating convenience of a common or contract carrier, and any such stoppage shall be considered as a continuity of movement and not as the storage of a hazardous substance. **[CERCLA 101(26)]**

Transuranic

Treatment Any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste or so as to render such waste nonhazardous, safer for transport, amenable for recovery, amenable for storage, or reduced in volume. Such term includes any activity or processing designed to change the physical form or chemical composition of hazardous waste so as to render it nonhazardous. **(DOE 1991)**

Treatment, storage, and disposal facility Any building, structure, or installation where a hazardous substance has been treated, stored, or disposed. TSD facilities are regulated by EPA and states under RCRA. **(DOE 1991)**

Trigger level

Tuff A compacted pyroclastic deposit of volcanic ash and dust that contains rock and mineral fragments incorporated during eruption or transport.

Type I error Incorrectly concluding that the null hypothesis is false. In remedial investigations the usual null hypothesis is that the site is contaminated. It is a Type I error to conclude that a site is not contaminated when it is. In routine monitoring, the null hypothesis may be that the site is not contaminated; it is a Type I error to conclude that the site is contaminated when, in fact, it is not. **(1122)**

Type II error Incorrectly concluding that the null hypothesis is true. In remedial investigations the usual error is concluding that a site is contaminated when it is not. In routine monitoring, it may refer to failure to detect contamination. **(1122)**

Ultimate disposal The final disposal of hazardous substances resulting from a removal action. It does not include temporary storage or other temporary measures of managing the waste from a removal action. **(DOE 1991)**

Unanticipated processes and events Those processes and events affecting the geologic setting that are nudged not to be reasonably likely to occur during the period the intended performance objective must be achieved, but which are nevertheless sufficiently credible to warrant consideration. Unanticipated processes and event s may be either natural processes or events or processes and events initiated by human activities other than those activities licensed under this part. Processes and events initiated by human activities may only be found to be sufficiently credible to warrant consideration if it is assumed that (1) the monuments provided for by this part are sufficiently permanent to serve their intended purpose; (2) the value to future generations of potential resources within the site can be assessed adequately under the applicable provisions of this part; (3) an understanding of the nature of radioactivity, and an appreciation of its hazards, have been retained in some functioning institutions; (4) institutions are able to assess risk and to take remedial action at a level of social organization and technological competence equivalent to, or superior to, that which was applied in initiating the processes or

events concerned; and (5) relevant records are preserved , and remain accessible, for several hundred years after permanent closure. **(10 CFR 60.2)**

Underground storage tank As defined in Section 9001(1) of the Solid Waste Disposal Act, the term "underground storage tank" means any one or combination of tanks (including underground pipes connected thereto) which is used to contain an accumulation of regulated substances, and the volume of which (including the volume of the underground pipes connected thereto) is 10% or more beneath the surface of the ground. Such term does not include any

(A) farm or residential tank of 1,100 gallons or less capacity used for storing motor fuel for non-commercial purposes;

(B) tank used for string heating oil for consumptive use on the premises where stored;

(C) septic tank;

(D) pipeline facility (including gathering lines) regulated under

i) the Natural Gas Pipeline Safety Act of 1968 (49 USC App. 1671 et seq.),
II) the Hazardous Liquid Pipeline Safety Act of 1979 (49 USC App. 2001 et seq.), or
III) which is an intrastate pipeline facility regulated under state laws comparable to the provisions of law referred to in Clause (i) or (II) of this subparagraph;

(E) surface impoundment, pit, pond, or lagoon,
(F) storm water or waste water collection system;
(G) flow-through process tank;
(H) liquid trap or associated gathering lines directly related to oil or gas production and gathering operations; or
(I) storage tank situated in an underground area (such as a basement, cellar, mine working, drift, shaft, or tunnel) if the storage tank is situated upon or above the surface of the floor.

The term UST shall not include any pipes connected to any tank which is described in Subparagraphs A through I. **(DOE 1991)**

United States Geological Survey

Unrestricted area Any area, access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials and any area used for residential quarters. **(10 CFR 60.2)**

Unsaturated zone The zone between the land surface and the regional water table. Generally, fluid pressure in this zone is less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies the fluid pressure locally may be greater than atmospheric. **(DOE 1991)**

Uranium A naturally radioactive element with the atomic number of 92 (number of protons in nucleus) and an atomic weight of approximately 238. The two principal naturally occurring isotopes are the fissionable ^{235}U (0.7% of natural uranium) and the fertile ^{238}U (99.3% of natural uranium. **(DOE 1991)**

Validation

Value engineering

Variable Component of a conceptual model described by a set of feasible values. **(Campbell)**

Variable, auxiliary A population parameter that is known or can be easily observed for all members of the population, whether or not included in a sample. **(Campbell)**

Variable, outcome A population parameter that can be observed for each specimen that is included in a sample. **(Campbell)**

Variance

Variance of a real random variable The centered second moment of the probability distribution of a real random variable; symbolically,

$$\int_{x \in S}^{?} (x-\mu)^2 \, dP(x),$$ where m is the expected value of the probability distribution. **(Campbell)**

Vector variable A variable whose set of feasible states is a subset of a finite-dimensional Euclidean space.

Volatile organic compound An organic (carbon-containing) compound that evaporates (volatilizes) readily at room temperature. **(DOE 1991)**

Voluntary corrective action (VCA) Selection and implementation of an obvious and effective corrective action during or following the RFI. **(Campbell)**

Water table That surface in a groundwater body at which the water pressure is atmospheric. **(10 CFR 60.2)**

Work breakdown structure

Working group

Xenocryst A crystal foreign to the igneous rock in which it occurs **(1122)**

Zeolite Any of a group of approximately thirty hydrous aluminum silicate minerals. **(1122)**