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Human Health Risk-Based Screening Methodology, Revision 2

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Acronyms and Abbreviations

ABS	skin absorption factor
AF	adherence factor
ALARA	as low as reasonably achievable
AOC	area of concern
ATSDR	Agency for Toxic Substances and Disease Registry
CME	corrective measures evaluation
COPC	chemical of potential concern
CSM	conceptual site model
DDD	p,p'-dichlorodiphenyldichloroethane
DDE	p,p'-dichlorodiphenyldichloroethylene
DDT	p,p'-dichlorodiphenyltrichloroethane
DOE	Department of Energy
DOE-AL	Department of Energy-Albuquerque Office
EP	Environmental Programs (a Laboratory directorate)
EPA	Environmental Protection Agency
EPC	exposure point concentration
ESL	ecological screening level
GI	gastrointestinal (tract)
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
IEUBK	Integrated Exposure Uptake Biokinetic
IRIS	Integrated Risk Information System
LANL	Los Alamos National Laboratory

MCL	maximum contaminant level
MDA	material disposal area
MRL	minimal risk level
NCEA	National Center for Environmental Assessment
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
PEF	particulate emission factor
PPRTV	provisional peer reviewed toxicity values
PRG	preliminary remediation goal
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RESRAD	residual radioactivity (computer code)
RfD	reference dose
SAL	screening action level
SF	slope factor
SSL	soil screening level
SWMU	solid waste management unit
TA	technical area
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TEF	toxicity equivalency factor
TEQ	toxic equivalent
UCL	upper confidence limit
UTL	upper tolerance limit
VF	volatilization factor
VOC	volatile organic compound

1.0 INTRODUCTION

A risk screening assessment is the initial step used to evaluate the potential risk to human (and ecological) receptors at sites influenced by the Los Alamos National Laboratory (LANL or the Laboratory) activities and is part of the Environmental Programs (EP) Directorate's approach to the Resource Conservation and Recovery Act (RCRA) corrective action process. The installation work plan describes how the screening assessment relates to the overall corrective action approach (LANL 1998, 062060). The main purpose of the screening assessment is to provide a simple but scientifically sound approach to streamline the assessment process. Using the screening assessment in the context of estimating potential risk at a site is at the discretion of the risk assessor; that is, a baseline risk assessment may be conducted at any site if the risk assessor determines it to be more appropriate than a screening assessment. The screening and/or baseline risk assessment(s) for a site is presented either in a risk assessment appendix or a standalone report.

The risk assessment report/appendix format presented in the Compliance Order on Consent (hereafter, the Consent Order), signed on March 1, 2005, is included in Appendix A. The risk assessment appendixes containing human health and ecological risk screening assessments, submitted as part of previous investigation reports, are the template for all subsequent submittals. The organization, content, language, figures, and tables for human health and ecological risk screening assessments from the most recently submitted appendixes are to be used to write the risk appendix in future reports. The appendixes to be used can be obtained electronically from the Risk Assessment Project Leader and from the EP-Environment and Remediation Support Services webpage. Additional example risk appendixes will be provided as reports are submitted to and accepted by the New Mexico Environment Department (NMED). Language common to all risk assessments (human health and ecological) is used as presented or modified to fit the specific sites being evaluated. Meetings with the Risk Assessment Project Leader before conducting and writing the screening or baseline risk assessments are essential to ensure consistency, accuracy, and completeness of the risk appendix.

The screening assessment is most useful for sites with a limited number of contaminants and where land use and potential exposures are well-defined. However, the screening assessment may also be useful in identifying key contaminants and exposure routes at a complex site. When contaminant transport and exposure assessment require complex modeling efforts, screening assessments have limited utility, and a baseline risk assessment should be used. Based on the results of the screening assessment, a site may be proposed for no additional evaluation of potential risk, further site investigation requiring more sampling and a baseline risk assessment, remediation, or a corrective measures evaluation (CME). Because potential risk is only one aspect of site evaluation, the determination of acceptable risk (human health and ecological) does not translate into a recommendation that no additional sampling or corrective action is necessary until other aspects of the investigation are satisfactorily resolved.

This document provides guidance to the project risk assessors performing risk-based screening assessments of solid environmental media (i.e., soil, sediment, and tuff) at Laboratory sites. Screening assessments of water are either based on a comparison to the appropriate federal and state water quality standards per the Consent Order or are risk-based, which incorporates the parameters used in previous reports, such as the Los Alamos Pueblo Canyons investigation report (LANL 2004, 087490) and the Mortandad Canyon investigation report (LANL 2006, 094161). Implementation of this methodology will ensure consistency in screening assessment activities. This document is meant primarily as internal guidance for project risk assessors and not as a reference in reports. Appropriate citations of NMED and U.S. Environmental Protection Agency (EPA) Region 6 guidance are to be included in the reports as the primary sources of the exposure scenarios, screening levels, and applications. A human health risk-

based screening assessment may be the only assessment of potential risk conducted for a site but could lead to a baseline risk assessment if results warrant it. This guidance is applicable to evaluating individual solid waste management units (SWMUs) or areas of concern (AOCs), consolidated units, aggregated units, watershed aggregates, or watersheds. In this document, the term "site" refers to all of these areas.

2.0 SCREENING ASSESSMENT APPROACH

The human health risk-based screening assessment approach follows the process described in the NMED technical background document for developing soil screening levels (SSLs) (NMED 2006, 092513, or latest version). A fundamental requirement is that a screening assessment cannot be performed until the nature and extent of contamination at a site have been determined. Initially, the existing data and information are assessed to determine whether they are sufficient in quantity and quality to conduct a screening assessment (LANL 1998, 062060). Subsequently, inorganic chemical and radionuclide data are compared to background or fallout concentrations based on the latest version of Standard Operating Procedures 5086, Background Value Comparisons—Inorganic Chemicals, and 5087, Background Value Comparisons—Radionuclides. Fallout radionuclides at depth and organic chemicals are evaluated based on detection status because background data are not available or not applicable.

The data review identifies chemicals that may be related to a release from a site and that may pose a potential risk to human health. These chemicals are referred to as chemicals of potential concern (COPCs). A human health screening assessment for surface, shallow subsurface, and subsurface soil/fill/tuff is conducted on the COPCs identified by the data review.

2.1 Conceptual Site Model

A conceptual site model (CSM) is developed to identify likely source areas and mechanisms of transport as well as the exposure pathways, exposure assumptions, and potential receptors. The CSM also discusses the fate and transport of COPCs detected at the site. The discussion of fate and transport includes the potential migration of each COPC in each medium, potential breakdown products (if any) and their migration, and anticipated pathways of exposure for human receptors. The fate and transport discussion summarizes the potential mobility of COPCs, the potential for COPCs to partition or adsorb to soil/tuff, and physical/chemical properties of COPCs such as water solubility and vapor pressure. The primary factor that is important with respect to the potential for COPCs to migrate to groundwater is the presence of saturated conditions. Downward migration in the vadose zone is limited by a lack of hydrostatic pressure as well as the lack of a source for the continued release of contamination. Without sufficient moisture and a source, little or no potential migration of materials occurs through the vadose zone to groundwater. Fate and transport text and tables are standardized in previous reports and are used with appropriate modifications for each investigation report (see Appendix B for examples of tables presenting soil-water partition coefficients [K_ds] and physical chemical properties to be used in the discussion of fate and transport). In addition, volatile organic compounds (VOCs) detected in pore gas must be evaluated for their potential to migrate to groundwater. The screening evaluation is presented in the risk assessment appendixes in previously submitted reports to NMED and is the process to be followed. The risk assessor must consult with the Risk Assessment Project Leader before conducting this evaluation.

The primary exposure media for receptors are surface soil and subsurface soil/tuff that may be brought to the surface through on-site activities. Surface water and/or groundwater are typically not an exposure medium at mesa-top sites but may be in the canyons. Human receptors (regardless of the exposure scenario) may be exposed to surface soil and subsurface soil/tuff through direct contact with soil or

suspended particulates by ingestion, inhalation, dermal contact, and external irradiation pathways. Exposure pathways to water also include ingestion (incidental or drinking water), inhalation, dermal contact (e.g., wading or swimming), and external irradiation. The industrial and recreational pathways are from surface (0- to 1-ft depth) exposures and do not typically include exposures to subsurface soil. The residential pathways are from surface and subsurface soil/tuff (0- to 10-ft) exposures because the residential scenario incorporates potential exposure to subsurface soil/tuff. The 0- to 10-ft depth used for the residential screening is also applied to the construction worker scenario. Because different depth ranges are used for each assessment, the COPCs and the concentrations to which receptors are exposed in the risk screening assessments vary depending on the depth at which the COPC is detected. In addition, if the elevated concentrations occur at depths below the exposure depth for a scenario, the COPCs are not evaluated for potential risk/dose.

For human health screening risk assessments, the CSM includes the current and reasonably foreseeable land use and residential land use (if not the current and reasonably foreseeable land use) for all sites investigated. Exposure to groundwater and/or surface water is only included in the CSM if complete pathways exist on-site, not off-site; stormwater runoff is not considered to be a complete exposure pathway for most sites. Exposure from subsurface vapor intrusion should be included in the CSM if pore-gas data have been collected. In the CSM, this exposure medium and pathway are likely to be hypothetical unless a building is already present at the site. Exposure parameters and the source of the values are presented within the risk assessment. A diagram of the CSM should also be included in the report (see Appendix B for an example of this figure).

The land use and exposure scenario used for decisions on sites are based on current conditions as well as likely planned uses (i.e., reasonably foreseeable future land use). Decision scenarios may be residential, industrial, or recreational, while a construction worker scenario may also be evaluated as a possible activity for a site. The decision scenario(s) is chosen following project team review of the Laboratory's 10-yr comprehensive site plan, consultation with facility managers and institutional planning personnel, discussion with county officials, review of land transfer proposals, and review of site operations. The decision scenario(s) dictates how the site is classified and whether the site remains on the permit but is administratively complete or is removed from the permit with all investigations and corrective actions concluded. The only land use under which a site is classified as "Corrective Action Complete without Controls" (all investigations and corrective actions are concluded) is the residential scenario. All other land uses result in a classification of "Corrective Action Complete with Controls"; that is, additional investigations or corrective actions may be warranted if the land use (decision scenario) changes.

More than one scenario may be evaluated for a site, but only the most conservative of the applicable current and reasonably foreseeable future land uses is used as the basis for recommendations and determining site status. For example, if the current and reasonably foreseeable future land use includes both industrial and recreational exposures, the industrial scenario is used to make decisions about the site because it has a more intense exposure. On the other hand, if the current and reasonably foreseeable future land use is industrial but the site meets the residential risk levels, the residential land use is used to decide the site status. All sites are evaluated for residential exposure regardless of whether this scenario is the current and reasonably foreseeable future land use or whether the results of the risk screening assessment satisfies residential risk requirements. In addition, the construction worker scenario is evaluated for any site where this activity is likely to occur.

2.2 Concentrations Used to Estimate Potential Risk

The key to all risk assessments is the calculation of the exposure point concentration (EPC). The EPA recommends using the average concentration to represent a reasonable estimate of the concentration likely to be contacted over time. EPA guidance goes on to say that "because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used for this variable" (EPA 1989, 008021). In some cases, the maximum detected concentration of a COPC is used as the EPC. The maximum detected concentration is used if a representative 95% UCL cannot be calculated. A nonrepresentative 95% UCL occurs if too few sample results are available to calculate a value or if the 95% UCL exceeds the maximum concentration in the data set.

The EPA has issued guidance for calculating the UCL of the unknown population mean for hazardous waste sites (EPA 2002, 085640), and ProUCL software has been developed to compute an appropriate 95% UCL of the unknown population mean. All UCL computation methods contained in EPA guidance are available in ProUCL (current version available at http://www.epa.gov/nerlesd1/tsc/software.htm). Additionally, ProUCL can compute a 95% UCL of the mean based upon the gamma distribution, which is better suited to model positively skewed environmental data sets. ProUCL tests for normality, lognormality, and a gamma distribution of the data set and computes a conservative and stable 95% UCL of the unknown population mean. The computation of an appropriate 95% UCL is based on the assumption that the data set under study consists of observations from only a single population. One-half of the detection limits is typically substituted as the concentration of the COPC in all statistical calculations for nondetections (EPA 1989, 008021).

Several parametric and distribution-free nonparametric methods are included in ProUCL. The UCL computation methods in ProUCL cover a wide range of skewed data distributions arising from the various environmental applications. For lognormally distributed data sets, the use of Land's H-statistic often yields unrealistically large and impractical UCL values. This occurrence is prevalent when the sample size is small and the standard deviation of the log-transformed data is large. The gamma distribution has been incorporated in ProUCL to model these types of positively skewed data sets. A UCL of the mean based upon a gamma distribution results in reliable and stable values. It is always desirable to test if an environmental data set follows a gamma distribution. For data sets (of all sizes) that follow a gamma distribution, the EPC should be computed using an adjusted gamma UCL of the mean or an approximate gamma UCL of the mean. These UCLs approximately provide the specified 95% coverage to the population mean. A 95% UCL may be obtained using the bootstrap-t method or Hall's bootstrap method when the sample size is small ($n<15$), and for larger samples, a UCL of the mean should be computed using the adjusted or approximate gamma UCL.

Text from previous risk assessment appendixes is used to describe the approach to determine the EPCs. The descriptions must include background information, guidance used to calculate 95% UCLs, the results of the distribution testing, and the methods used to calculate the EPCs. The text may also include the equations for each applicable calculation method. The results of the distribution testing of data for each exposure scenario, the methods used to calculate the EPCs, the statistics for each COPC and EPC, and the EPCs must be presented in tables in the risk appendix. If the maximum detected concentration is used, the text must explain the basis for using this EPC and a table summarizing the maximum detected concentrations is provided. Tables from previous risk assessment appendixes are used to present this information (see Appendix B for an example of the table).

2.3 Screening Levels for Soil

The screening assessment process involves comparing chemical data to risk-based concentrations and radionuclide data to dose-based concentrations to determine if a potential for unacceptable risk to human health exists at the site. The risk-based concentrations for chemicals used in this comparison are referred to as SSLs, while the dose-based concentrations for radionuclides are referred to as screening action levels (SALs). An SSL/SAL is the concentration of a chemical or a radionuclide at or below which no potential unacceptable risk or dose exists, respectively, to human health as defined by a specific exposure scenario under certain exposure parameters. The CSM is developed to ensure the exposure pathways, exposure assumptions, and potential receptors match those used to calculate the SSL/SAL. The CSM represents links between the various aspects of the site in question and summarizes current understanding of the contamination. The information is used to determine the applicability of SSLs/SALs at the site and the need for an alternative approach. For example, if additional, complex exposure pathways may be relevant in describing the site exposure scenario (e.g., meat-ingestion or drinking-water pathways), the CSM does not coincide with the SSL/SAL assumptions and a screening assessment is not appropriate. In these instances, a site-specific baseline risk/dose assessment is conducted.

The SSLs/SALs have been developed for chemicals and radionuclides based on residential, industrial, construction worker, and recreational exposure scenarios. The SSLs/SALs are intended to be applied to surface and near-surface soils and sediments and are generally useful to a depth of approximately 10 ft, which accounts for possible construction-related excavation and/or residential exposure. Contaminants occurring at depths greater than 10 ft may require evaluations other than, or in addition to, the SSL/SAL comparisons described (e.g., transport to groundwater) and their use is at the discretion of the risk assessor.

Chemical SSLs

Chemical SSLs used in a screening assessment are based on chronic toxicity and not acute toxicity. The SSLs used in the human health screening assessments for residential, industrial, and construction worker exposures are those provided in the NMED guidance document (NMED 2006, 092513, or latest version). If NMED does not provide a residential or industrial SSL for a chemical, EPA Region 6 human-health medium-specific screening levels are used (EPA 2006, 094321, or latest version) or EPA Region 9 preliminary remediation goals (PRGs) (epa.gov/region09/waste/sfund/prg/files/04prgtable.pdf or latest version) are substituted if EPA Region 6 also does not have a value. Total chromium and inorganic mercury are routinely evaluated using EPA Region 6 screening levels instead of NMED SSLs because of the nature of the analytical results (NMED has SSLs only for chromium(III), chromium(IV), elemental mercury, and methyl mercury). In addition, the total uranium SSL is available only from EPA Region 9. Recreational SSLs are obtained from a Laboratory guidance document (LANL 2007, 094496, or latest version).

A chemical SSL represents the concentration of a chemical associated with either a total lifetime excess cancer risk of 1 in 100,000 (10^{-5}) for carcinogens or a hazard quotient (HQ) of one (1.0) for noncarcinogens. These target levels are in agreement with the NMED technical background document for developing screening levels (NMED 2006, 092513, or latest version) but differ from the EPA Region 6 human health medium-specific screening levels for carcinogens (EPA 2006, 094321, or latest version). The EPA Region 6 guidance uses a 10^{-6} cancer-risk level for the SSL for each chemical carcinogen. In either case, the methodology for calculating chemical SSLs uses current toxicity values, parameters, and equations (see Appendix B for an example of the tables).

Generally, if both noncarcinogenic and carcinogenic toxicity criteria have been established for a chemical, the criterion resulting in the lowest SSL is used in the screening assessment because if the lower value is not exceeded by the site concentration, neither toxicity-effect category is of concern. A screening assessment for chemical carcinogens uses the NMED SSL based on a 10^{-5} cancer risk. As a result, the NMED SSL for a chemical may be a noncarcinogenic value rather than a carcinogenic value, as presented by EPA Region 6 (EPA 2006, 094321, or latest version) (i.e., the value based on noncarcinogenic effect may be lower than that based on 10^{-5} cancer risk versus EPA Region 6 10^{-6} cancer risk). The evaluation of some COPCs for both carcinogenic and noncarcinogenic effects is typically up to the risk assessor and might involve calculating the other SSL using NMED equations and parameters (NMED 2006, 092513, or latest version). Some chemicals (i.e., arsenic, Aroclor-1254, and Aroclor-1260) should be evaluated for both types of effects in all instances where they are retained as COPCs. The carcinogenic and/or noncarcinogenic SSLs for these COPCs can be obtained from EPA Region 6 (EPA 2006, 094321, or latest version) and should be used in the screening assessment along with the SSLs from NMED guidance (NMED 2006, 092513, or latest version).

Several inorganic and organic chemicals have NMED SSLs based on a maximum allowed concentration of 100,000 mg/kg (NMED 2006, 092513, or latest version; EPA 2006, 094321, or latest version). This value is not a risk-based SSL, and the assignment of a maximum allowed concentration indicates the toxicity of the COPC is negligible. The chemicals with NMED SSLs for one or more scenarios based on a maximum allowable concentration include acetone, aluminum, anthracene, barium, benzoic acid, boron, butylbenzylphthalate, chromium(III), diethylphthalate, dimethyl phthalate, iron, nitrate, nitrite, phenol, strontium, and zinc.

For some organic chemicals, the NMED, EPA Region 6, and/or Laboratory SSLs are based on the soil saturation concentration (C_{sat}) (NMED 2006, 092513, or latest version; EPA 2006, 094321, or latest version; LANL 2007, 094496, or latest version). However, the C_{sat} is unrelated to the potential for adverse toxicological effects and is not intrinsically meaningful in the context of a risk assessment. All VOCs that have C_{sat}-based SSLs should also be evaluated for potential risk. This evaluation can be conducted by calculating an SSL using only the soil-ingestion and dermal-absorption pathways, obtaining a risk-based screening level from the EPA Region 6 spreadsheet (http://www.epa.gov/region06/6pd/rcra_c/pd-n/screenexpanded.xls), or performing a forward risk calculation using the models and parameter values for the scenario-specific SSLs (NMED 2006, 092513, or latest version; EPA 2006, 094321, or latest version; LANL 2007, 094496, or latest version). The evaluation of VOCs using the C_{sat} and risk-based concentrations is discussed in more detail in Section 3.1.1.

According to NMED guidance (NMED 2006, 092513, or latest version), the SSLs do not account for vapor intrusion and inhalation of VOCs volatilized into indoor air. If vapor intrusion into indoor air is a concern or a potential complete exposure pathway (i.e., pore-gas data are available and indicate VOCs are present in the pore gas, additional analysis of this pathway may be necessary). Comments from NMED in notices of disapproval have stated that this pathway must be assessed using available draft EPA guidance (http://www.epa.gov/correctiveactions/eis/vapor.htm and http://www/epa/gov/swerrims/riskassessment/airmodel/johnson_ettinger.htm). If the vapor intrusion pathway is complete or is potentially a complete exposure pathway, the risk assessor must discuss the approach for evaluating the potential risk with the Risk Assessment Project Leader.

Radionuclide SALs

The SALs for radionuclides are based on dose rather than carcinogenic risk and are calculated using the residual radioactive (RESRAD) materials computer code developed by Argonne National Laboratory for the U.S. Department of Energy (DOE) (web.ead.anl.gov/resrad/home2/). The RESRAD code has been

revised continually and improved since it was issued in 1989. The RESRAD model and parameters used to calculate SALs are reviewed annually (at the start of each fiscal year [October]) to determine whether the values need to be updated. Because RESRAD may be revised one or more times a year, radionuclide SALs are revised only if the latest version of the RESRAD code affects the calculations. The revised radionuclide SALs (if any) are implemented at the beginning of a fiscal year; new values are not retroactive. The most recent manual describing the use of the RESRAD code was published in July 2001 (Yu et al. 2001, 071420).

The dose limit used as the basis for radionuclide SALs at a single site is 15 mrem/yr (DOE 2000, 067153). The dose limit is consistent with regulatory guidance and satisfies the "as low as reasonably achievable" (ALARA) principle to ensure that radiation dose is minimized (DOE 2000, 067153). As a result, sites where radionuclide concentrations result in a dose greater than 15 mrem/yr (i.e., sites where radionuclide concentrations are greater than SAL or where exposure to multiple radionuclides results in an exceedance of the dose limit) are evaluated further. The derivation and use of SALs (residential, industrial, construction worker, and recreational) for radioactive COPCs is described in Laboratory guidance (LANL 2005, 088493).

The exposure scenarios for radionuclides are the same as for chemicals: residential, industrial, construction worker, and recreational. Standard default values similar to those used for chemical SSL calculations are incorporated into the RESRAD model with the doses summed over multiple pathways. Exposure pathways incorporated into the calculation of radionuclide SALs are the incidental ingestion of soil; inhalation; ingestion of homegrown fruits and vegetables (residential only); and external irradiation. Because certain radionuclides (particularly strontium-90) known to occur at some sites are susceptible to plant uptake, ingestion of homegrown produce (fruits and vegetables) is included among the potential pathways evaluated in calculating radionuclide SALs for a resident.

2.4 Screening Levels for Water

Surface water and groundwater may be screened as well if data are collected as part of the investigation or relevant data are available for the site(s) in question. Generally, complete exposure pathways to surface water and groundwater are not present for mesa-top sites. Surface water and groundwater data are typically obtained for the canyons investigations but not for individual SWMUs and AOCs. Water data are screened per the Consent Order, which requires a comparison of data collected to water quality standards (EPA maximum contaminant levels, New Mexico drinking water standards, and/or New Mexico groundwater and surface water standards). If a water quality standard is not available, the EPA Region 6 tap-water screening levels are used. Water data may also be evaluated for risk if the scenario includes potential exposure of a receptor. For example, a recreational scenario may include exposure to surface water if it is accessible to the receptor, is persistent enough to provide a complete exposure pathway, and can be result in a chronic exposure. Other scenarios (residential, industrial, and construction worker) are less likely to include surface water or groundwater in a risk-based screening assessment but should be evaluated on a case-by-case basis.

The evaluation of potential risk from exposure to surface water and groundwater should incorporate parameters used in previous reports (LANL 2004, 087390; LANL 2006, 094161), as appropriate, to ensure consistency in the screening assessment. If the potential exposure is different than that presented in previous assessments, exposure assumptions and parameters must be discussed with the Risk Assessment Project Leader before the screening assessment is conducted. In addition, the appropriateness of the evaluation of potential risk from exposure to surface water and groundwater must be discussed with the Risk Assessment Project Leader whenever a water screening assessment is considered.

2.5 Screening Assessment

The screening assessment should include sections discussing scoping, screening evaluation (comparison with SSLs/SALs), uncertainty analysis, and interpretation. If a baseline risk assessment is conducted, the screening comparison with SSLs/SALs may be incorporated into the risk assessment, or the comparison with SSLs/SALs is eliminated and all COPCs identified by the data review are evaluated in the baseline risk assessment.

2.5.1 Scoping

The scoping section must include a discussion of both current and reasonably foreseeable future land uses for a site as the key element that identifies appropriate receptors and exposure pathways. Potential transport and exposure pathways as well as a review of the site history (focusing on release mechanisms, potential contaminants, and contaminated media) are also important components of the scoping section.

In addition, the CSM is compared to exposure pathways and assumptions to document that the SSLs/SALs are applicable to evaluating potential human health risk at the site. The scoping section also should state whether the site is accessible and whether it is a secure area with limited and monitored access and egress. The CSM describes the current and reasonably foreseeable future land use for the site, which is the basis for corrective action decisions for the site. The section should also state whether the area is expected to be used exclusively for Laboratory operations in the future (i.e., industrial exposure) or whether other land-use scenarios for the site (e.g., recreational or residential) are possible.

2.5.2 Screening Evaluation

The screening evaluation portion of an assessment compares either the maximum detected concentration or the 95% UCL of the arithmetic mean concentration of each COPC with the appropriate SSL/SAL. Calculation of the 95% UCL is based on EPA guidance (EPA 2002, 085640), which is also the basis for the EPA software ProUCL. The choice of UCL calculation method is based on the distribution of the data (i.e., normal, lognormal, gamma, or nonparametric). A separate EPC is determined for each COPC for each scenario/receptor evaluated.

The SSLs/SALs used in the screening evaluation are based on the current and reasonably foreseeable future land use for the site. Currently, four types of exposures might be evaluated: residential, industrial, construction worker, and recreational. These exposures are represented by receptors evaluated under specific exposure conditions and include a resident (adult and child), an outdoor worker (adult), a construction worker (adult), and a trail user (adult and child), respectively. The child trail user is evaluated under an "extended backyard scenario," which assumes a child is playing in an area for an extended period of time. The depth intervals for each scenario differ in that some exposures assume no intrusion into the subsurface, while others assume intrusive activities. The industrial and recreational scenarios assume a surface exposure (0 to 1 ft) to either a site worker or a trail user. The residential and construction worker scenarios assume some subsurface exposure: the residential is usually 0 to 10 ft, and the construction worker is site-specific, depending on the potential or proposed construction activity. The default depth interval for construction worker exposure is 0 to 10 ft if specifics are not known. If the COPCs occur below the exposure depth for a scenario, the COPCs may not be evaluated further. The screening evaluation uses the SSLs/SALs calculated for the particular land use/receptor, which is the basis for a decision.

A comparison to residential SSLs/SALs must be conducted for informational purposes for each site where residential is not the decision scenario. If the site passes the residential scenario, regardless of whether it

is the current and reasonably foreseeable future land use for the site, the results are presented as the decision basis because it is the only scenario that results in the site being categorized as "Corrective Action Complete without Controls." All such decisions should be discussed with the project leader before they are presented in a report.

Comparisons to SSLs/SALs for carcinogenic, noncarcinogenic, and radionuclide COPCs are performed separately.

- *Carcinogens.* All chemical carcinogens are compared with their respective SSLs.

  Each SSL represents a 10^{-5} (1 in 100,000) incremental excess cancer risk to an individual. The total incremental excess cancer risk (sum of cancer risk for all carcinogenic COPCs) is also compared to a 10^{-5} cancer risk level (NMED's target risk level for carcinogens). To conclude that no potential unacceptable risk exists to human health, NMED's target risk level of 10^{-5} must be met. However, EPA has established a target risk range for carcinogens of 10^{-4} to 10^{-6} (EPA 1990, 055594). If NMED's 10^{-5} target risk level is exceeded but is within the EPA target risk range, further evaluation or discussion is necessary to determine whether potential unacceptable risk to human health exists at a site.

- *Noncarcinogens.* All chemical noncarcinogens are compared with their respective SSLs.

  Each SSL is equivalent to a HQ of 1.0, which represents the concentration at or below which no human health hazard is expected. The ratio of the exposure concentration for each noncarcinogenic COPC to its respective SSL or HQ and the sum of individual ratios or hazard index (HI) for noncarcinogenic COPCs must be less than or equivalent to 1.0 to conclude that no potential unacceptable hazard to human health exists.

- *Radionuclides.* All radionuclides are compared with their respective SALs.

  Each SAL represents a dose of 15 mrem/yr. The total dose for all radionuclides detected above background/fallout levels must be less than or equivalent to 15 mrem/yr to safely conclude that no potential unacceptable dose exists.

The above comparisons are based on guidance from NMED (NMED 2006, 092513, or latest version); EPA Region 6 (EPA 2006, 094321, or latest version); and DOE (DOE 2000, 067153). If the above conditions are met, the site needs no further evaluation of human health risk, and the site may be recommended for complete with or without controls, depending on the scenario used. As a result of the SSL/SAL comparison, each COPC falls into one of the following categories: greater than SSL/SAL, no SSL/SAL, or less than/equal to SSL/SAL. Appendix B presents examples of the tables for the risk-screening comparisons to be included in the risk assessment appendix as well as other tables necessary to document the process.

Greater than SSL/SAL indicates that the EPC (e.g., the maximum detected concentration or the 95% UCL of the mean concentration) is greater than the SSL/SAL, or the HI, total incremental excess cancer risk, or total dose are greater than the appropriate target level. Any COPC in this category is evaluated further within the screening assessment or as part of a baseline risk assessment.

No SSL/SAL indicates no SSL/SAL is currently available for comparison. For many of these chemicals, it may be appropriate to use an SSL/SAL based on toxicological/molecular structural information for similar chemicals (i.e., a surrogate) or to calculate an SSL/SAL based on available toxicity information. The calculated SSL/SALs must be approved by the Risk Assessment Project Leader. If SSLs/SALs for surrogate chemicals are used in the screening evaluation, the rationale for their use must be presented in

the screening evaluation. Commonly used surrogate chemicals are listed in Appendix C of this document (see also NMED memorandum on the use of surrogates [NMED 2003, 081172]).

Samples are routinely analyzed for several inorganic chemicals (e.g., calcium, magnesium, potassium, and sodium) that are essential nutrients and for which SSLs have not been developed because low-dose toxicity information is insufficient. These chemicals occasionally are detected at concentrations greater than background and therefore may be retained as COPCs. However, if the concentrations are only slightly elevated above background levels (e.g., less than twice the background value), EPA's Risk Assessment Guidance for Superfund (RAGS), Part A (EPA 1989, 008021), indicates that essential nutrients can be eliminated without further evaluation. In addition, if the elevated concentrations occur at depths below the assumed exposure depth for a scenario, these inorganic chemicals are eliminated without further evaluation. The potential importance of these chemicals as toxicants may be assessed according to human nutritional requirements.

Less than SSL/SAL indicates the EPC (e.g., the maximum detected concentration or the 95% UCL of the mean concentration) is less than the SSL/SAL, or the HI, total incremental excess cancer risk, or total dose are less than the appropriate target level. The COPCs in this category generally do not pose an unacceptable risk to human health and are not evaluated further.

Chemicals not detected in any sample generally are not included in a screening assessment when sample-specific detection limits do not exceed the contract-required detection limits for EPA Contract Laboratory Program analytical methods or equivalent methods presented in the analytical statement of work (LANL 2000, 071233). Exceptions may be invoked if a detection limit is greater than background for inorganic chemicals or greater than SSLs for organic chemicals and if the inorganic or organic chemical is suspected at a site. Factors to consider when determining whether chemicals reported as "nondetects" are retained as COPCs in the screening assessment include

- site process knowledge that the chemical or related chemicals were used;
- the presence of related chemicals or chemicals of a degradation chain;
- the magnitude of the discrepancy between the detection limit and SSL (if the detection limit is close to the SSL, the chemical may be retained, but if the detection limit is several times less than the SSL, the chemical may be eliminated);
- the number of samples collected (analyzing only a few samples may not define the nature of contamination, and thus some chemicals may not be eliminated); and
- the applicability of the SSL assumptions at the site in question.

These factors can also be used to determine whether a chemical with elevated sample-specific detection limits (e.g., resulting from matrix interference) is retained or eliminated as a COPC. If a chemical reported as not detected is retained as a COPC, the maximum detection limit for that chemical is used in the screening assessment as the EPC. The rationale for eliminating or retaining a chemical with elevated detection limits as a COPC is documented on a chemical-by-chemical basis.

2.5.3 Uncertainty Analysis

The uncertainty analysis presents a qualitative assessment of issues that potentially may affect the results of the screening evaluation and assists in interpreting the results. The analysis includes issues related to data quality, receptors and exposure pathways, SSL/SAL calculations, exposure and toxicity assessments, and surrogate chemicals used in the SSL comparisons. The uncertainty analysis also evaluates COPCs retained by the screening evaluation to determine whether they are eliminated or

carried forward to a risk assessment or corrective action, and details the rationale for eliminating any COPCs based on process knowledge (or other sound reasons). A qualitative discussion justifying eliminating or retaining COPCs that were not screened should also be included. The uncertainty analysis may result in adding or deleting COPCs.

Areas of uncertainty that may need to be discussed include, but are not limited to,

- the definition of the physical setting (the likelihood that the receptor and pathways are appropriate);
- data quality issues, such as qualifiers indicating high/low bias;
- analytical methods used;
- environmental transport models;
- chemicals with detection limits that exceed their respective SSLs;
- toxicity values used (e.g., use of any surrogate chemicals);
- intake/exposure parameters and their assumed values;
- receptor(s) and land-use scenario(s) identified;
- assumptions about multiple pathway exposure;
- derivation of the EPC; and
- differences in the toxic endpoints (target organs) among noncarcinogens.

2.5.4 Interpretation

The interpretation portion of the screening assessment summarizes the results of the human health screening assessment with respect to the uncertainty analysis. The uncertainty analysis leads to conclusions regarding the potential risk to receptors and increases the confidence level in the assessment results. The interpretation portion also identifies COPCs retained by the screening evaluation and evaluates the subsequent steps for further evaluation. For example, a COPC above its SSL/SAL may indicate subsequent action at the site is warranted (e.g., remediation), or it may indicate a site-specific baseline risk assessment should be conducted based on the current and reasonably foreseeable future land use. The results of the risk assessment are used to determine whether additional investigation or corrective action is warranted.

The DOE has an agreement in principal with NMED regarding risk from radionuclides. Per the agreement, the Laboratory provides the equivalent total radionuclide risk level for each site that is the subject of an environmental investigation. The equivalent total risk is provided for the decision scenario(s), which is the basis for the recommendations and conclusions for the site(s). For residential and industrial exposures, the exposure concentrations for radionuclides are compared to EPA's PRGs for radionuclides presented at *http://epa-prgs.ornl.gov/radionuclides/download/rad_master_prg_table_pci.xls*. Risks are estimated by determining the ratio of exposure concentration to the PRG, adding the ratios and multiplying by 10^{-5}. For construction worker exposures, the industrial PRGs for radionuclides are used to estimate the equivalent total risk. For recreational exposures, the RESRAD computer model is used to calculate 10^{-5} risk levels for radionuclide COPCs. Concentrations of radionuclides equivalent to 10^{-5} risk levels for recreational exposures calculated using RESRAD are provided in Appendix F.

3.0 DERIVATION OF SOIL SCREENING LEVELS FOR NONRADIOLOGICAL CHEMICALS

The approach described in this methodology is intended to ensure consistency in the calculation of SSLs and in their application for evaluating specific media. Independent calculation of SSLs that incorporates updated toxicity values in real time rather than on periodic updates from outside sources is also acceptable. However, any deviations from the procedure described in this document may be made only with approval from the Risk Assessment Project Leader.

The equations and parameter values presented in this methodology are consistent with those of NMED and EPA Region 6 in the derivation of their SSLs and medium-specific human health screening levels, respectively (NMED 2006, 092513, or latest version; EPA 2006, 094321, or latest version). If an SSL for a given scenario is not available for a COPC, three options are available for evaluating potential risk. One is to calculate an SSL using NMED equations and parameters, provided toxicity values are available in the recommended hierarchy of toxicological sources (section 3.1). This option may be the case for some COPCs under a construction worker scenario because NMED does not include all COPCs detected, and EPA Region 6 does not calculate construction worker SSLs. The second option is to use a chemical that is similar in structure or is a breakdown product of a parent compound that has an SSL. A surrogate is used if no toxicity information for the COPC is available to calculate an SSL (section 3.1). Finally, the COPC can be evaluated qualitatively if no toxicity information is available and a surrogate cannot be found. This evaluation can be done using, for example, frequency of detection, concentrations relative to detection limits and background, and process knowledge.

Lead is the exception to the SSL calculations described in this document and the other referenced documents because EPA-approved toxicity values for lead have not been published. The SSL for lead is based on the soil lead level that limits exposure of a child for a resident and trail user or fetus in the case of industrial exposure to no more than a 5% chance of exceeding a 10 µg/dL blood lead level (EPA 1994, 059509). The SSL for a child resident or trail user is calculated using EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model (EPA 1994, 059894). The SSLs for an adult worker/construction worker exposure are calculated based on EPA's adult lead model (EPA 2003, 086537). A comparison of site concentrations to these screening levels is the initial step in the screening assessment. The HQ for lead is an indication of whether the blood lead level criterion is exceeded for a given scenario. As long as the HQ and HI are less than 1.0, the blood lead level does not exceed 10 µg/dL, and no additional evaluation is necessary. If the HQ for lead exceeded 1.0, the blood lead level is greater than 10 µg/dL and corrective action may be warranted. If the HI exceeded 1.0 and lead was a major contributor, a separate evaluation of the blood lead level may be warranted in the uncertainty analysis. If the HI without lead does not exceed 1.0 and the lead level is less than the SSL (i.e., blood lead level of 10 µg/dL is not exceeded), no corrective action is necessary.

In addition, because certain inorganic and organic chemicals have relatively low toxicity, a nonrisk based maximum concentration of 10^5 (100,000) mg/kg is used when the calculated risk-based SSL exceeds this concentration (section 2.3).

3.1 Toxicity Values

Toxicity values (reference doses [RfDs] and cancer slope factors [SFs]) associated with chronic exposure are preferentially used to calculate SSLs. The toxicity values used in calculating chemical SSLs for residential, industrial, and construction worker exposures are presented in NMED, EPA Region 6, and EPA Region 9 guidance (NMED 2006, 092513, or latest version; EPA 2006, 094321, or latest version; epa.gov/region09/waste/sfund/prg/files/04prgtable.pdf or latest version) and are also used to calculate recreational SSLs (LANL 2007, 094496, or latest version). The recommended hierarchy of toxicological sources is described in an EPA memorandum (EPA 2003, 086554).The preferred source of toxicity

values is EPA's Integrated Risk Information System (IRIS) located at *http://www.epa.gov/iris/*. In addition, provisional peer reviewed toxicity values (PPRTVs) may be obtained for some chemicals and routes of exposure from EPA's National Center for Environmental Assessment (NCEA), which publishes issue papers on certain chemicals' toxicity values for use by EPA regional offices. However, the PPRTVs have not been subjected to rigorous scientific review and therefore cannot be used with the confidence of values obtained from IRIS. The PPRTVs are used in calculating SSLs for performing screening assessments because (1) they reflect the state of knowledge within NCEA at the time of their publication and therefore incorporate a level of review beyond peer-reviewed publications, and (2) they incorporate several upper-bound exposure estimates and conservatively biased submodels for dermal absorption and dust resuspension. Therefore, the uncertainty associated with the PPRTV is balanced by a bias toward protecting the public. If provisional values are used in SSL calculations for chemicals that are potential risk-drivers, the degree of confidence of the screening decision is discussed in the uncertainty analysis of the screening assessment. EPA's Health Effects Assessment Summary Table (HEAST) is also used as a source of toxicity values (EPA 1997, 058968) as well as the Agency for Toxic Substances and Disease Registry minimal risk levels (MRLs) (*http://www.atsdr.cdc.gov/mrls.html*).

EPA specifies separate toxicity values for ingestion and inhalation intake routes. Toxicity values for metals are not extrapolated between ingestion and inhalation exposure routes when a value has been published for one route only because of the potential differences in absorption efficiencies between these intake routes. Because absorption of organic chemicals more closely approximates 100% for both ingestion and inhalation, route-to-route extrapolation is performed. If extrapolated toxicity values between ingestion and inhalation exposure routes are used in SSL calculations for chemicals that are potential risk-drivers, the effects on the confidence of the screening decision are discussed in the uncertainty analysis.

EPA toxicity values for chemical ingestion are also used to evaluate risks associated with dermal absorption. Depending on the chemical and on the method of administration in the studies from which oral toxicity values are derived, oral toxicity values may reflect varying absorption efficiencies from the gastrointestinal (GI) tract into the bloodstream. Because specific information on absorption efficiency is rarely available, oral toxicity values used to evaluate risks associated with dermal absorption are not adjusted to account for the chemical-specific oral absorption fraction associated with the oral toxicity value. Using oral toxicity values without adjusting for GI absorption efficiency may result in an under- or overestimate of intake through the dermal pathway. However, this uncertainty is balanced by the conservative assumptions incorporated into the dermal absorption model, as discussed in section 3.3.3, Dermal Absorption.

The relative bioavailability of a chemical in the GI tract is not incorporated into the SSL calculations for the soil-ingestion pathway. In general, chemical bioavailability in soil is lower than in water because of the time required for a chemical to desorb from a soil particle and/or diffuse from within pores in the soil particle. Desorption rates are also generally longer for soil contamination than for "spiked" food used in laboratory toxicity studies because desorption rates are correlated with the length of time that a chemical has been sorbed. Some fraction of a chemical adsorbed onto soil may desorb at so slow a rate as to be effectively unavailable during the transit time through the GI tract. Factors such as chemical form, soil-particle diameter, geochemical factors, and individual nutritional status affect the degree of bioavailability from soil. The assumption of equivalent bioavailability from soil and from the administration vehicle used in the toxicity studies on which many toxicity values are based (e.g., food or water) results in an overestimation of uptake from soil ingestion.

Some chemicals routinely analyzed for, and detected, do not have EPA-approved or provisional toxicity values. In this case, a similar chemical for which toxicity values are available is identified and used as a surrogate in the screening assessment. The similarity may be based on its chemical structure or its being

a parent compound or degradation product of the chemical. Identifying an appropriate surrogate value and determining whether the evaluation is needed within the context of a screening assessment or a risk assessment are chemical-specific and assessment-specific decisions beyond the scope and purpose of this document. Surrogates and the assumptions affecting their choice and use are documented in each report, where applicable (see Appendix C of this document and NMED memorandum on surrogates [NMED 2003, 081172]).

3.2 Exposure Scenarios, Media, and Pathways

The SSLs represent exposure for several scenarios including residential, industrial, construction worker, and recreational. Sites screened and released on the basis of a residential exposure are also safe for recreational and industrial activities. Construction worker SSLs may be more restrictive than residential SSLs for certain chemicals. However, construction worker SSLs need to be used with caution because they represent an activity that lasts for only a few months or a year rather than a chronic exposure, as represented by the other scenarios. Therefore, it is unlikely sites will be released based solely on a construction work exposure, but that decision is made by the administrative authority. The restrictions of the SSLs with respect to media and depth were discussed in section 2. Exposure pathways for chemical SSLs include incidental ingestion of soil, inhalation of particulates and/or vapors in ambient air, and dermal absorption of chemicals in soil. If other pathways are thought to be important for a given site/receptor, chemical SSLs might not be applicable, and further analysis is warranted in a baseline risk assessment. Typically, the pathway for ingesting homegrown vegetables and fruit is not included in the assessment of chemical carcinogens and noncarcinogens and is not included in the NMED or EPA soil-screening methodologies.

Exposure equations and parameter values for SSL calculations are provided in this document (section 3.4, Soil Screening Level Equations and Parameter Values). The primary sources of exposure parameters used in SSL calculations are EPA's supplemental screening-level guidance (EPA 2001, 087462) and EPA's exposure factors handbooks, volumes 1, 2, and 3 (EPA 1997, 066596; EPA 1997 066597; EPA 1997, 066598) as well as NMED's guidance (NMED 2006, 092513, or latest version). Parameter values are intended to provide estimates of the reasonable maximum exposure for a receptor incorporating the pathways described in this section. Many of these exposure parameters describe the intensity, frequency, and duration of exposure. For the dermal absorption exposure route, parameter values for exposed body surface area, soil adherence factor, and skin absorption factors were obtained from EPA Region 6 guidance (EPA 2006, 094321, or latest version) and NMED (2006, 092513, or latest version). The values were obtained from EPA's dermal risk assessment guidance (EPA 2004, 090800).

3.3 Modeling Inhalation and Dermal Pathways

3.3.1 Inhalation—Volatile Organic Compounds

The concentration of VOC vapors in the ambient-air breathing zone associated with volatile organic chemicals in site soils is calculated using a steady-state volatilization model (EPA 1991, 058234). The version of the volatilization factor (VF) model used to calculate SSLs is presented in the user's guide and the technical background document of EPA's soil-screening guidance documents (EPA 1996, 058917; EPA 1996, 059902) and in EPA Region 6 and NMED guidance (EPA 2006, 094321, or latest version; NMED 2006, 092513, or latest version).

The VF model assumes an effectively infinite depth of contaminated soil and no cover of clean soil. This assumption may overestimate risk for sites with a relatively small volume of vapor-phase contamination. The VF model is valid for sites where a VOC is present at concentrations below soil-particle, pore-water, and pore-air saturation phases. For conditions in which soil is saturated with one or more organic

chemicals, an SSL calculated using the VF model output is not reliable. The screening value for a VOC under these conditions is the soil saturation concentration (C_{sat}). The VF and C_{sat} model equations and parameter values for SSL calculations are presented in section 3.4. The basis for setting an SSL at C_{sat} when the calculated inhalation SSL exceeds C_{sat} is EPA guidance that further investigation is generally warranted when free nonaqueous phase liquids are present in site soils (EPA 1996, 059902, section 2.4.4). This value is used to identify the possible presence of nonaqueous phase VOC liquid, which may result in a greater likelihood of off-site migration. However, EPA limits this recommendation for setting an SSL to C_{sat} when only the organic chemical is a liquid at ambient soil temperatures.

The NMED, EPA Region 6, and/or Laboratory SSLs for several VOCs are based on C_{sat} values (NMED 2006, 092513, or latest version; EPA 2006, 094321, or latest version; LANL 2007, 094496, or latest version). However, the C_{sat} values are not associated with toxicological endpoints, are unrelated to the potential for adverse effects, and are not intrinsically meaningful in the context of a risk assessment. Therefore, those VOCs that are likely to be liquid in subsurface soil or tuff and have one or more SSLs based on C_{sat} rather than chemical-specific toxicological effects must be evaluated using risk-based concentrations. Risk-based SSLs can be obtained either from the EPA Region 6 screening level spreadsheet (http://www.epa.gov/region06/6pd/rcra_c/pd-n/screenexpanded.xls) or by calculating an SSL using only the soil-ingestion and dermal-absorption pathways. Eliminating the inhalation pathway from this SSL calculation is consistent with EPA soil-screening guidance, EPA Region 6 soil-screening guidelines and NMED guidance (EPA 1996, 058917; EPA 2006, 094321, or latest version; NMED 2006, 092513, or latest version). EPA has stated that "the inhalation route is not likely to be of concern for those chemicals with (calculated) SSLs exceeding C_{sat} concentrations" (EPA 1996, 059902, section 2.4.4).

An alternative to calculating or obtaining a risk-based SSL is to perform a "forward" risk calculation to calculate the HQ for each VOC. If the site concentration exceeds the C_{sat} value, the chemical-specific C_{sat} value is used as the input concentration for the inhalation pathway for the forward risk calculation. For the remaining exposure pathways (ingestion and dermal), the actual site concentration(s) is used in the forward calculation. If the site concentration does not exceed the C_{sat} value, the site concentration is used for all of the exposure pathways. EPA has stated that volatile emissions reach a plateau at C_{sat} and do not increase even if free-phase liquid organic chemical is in fact present (EPA 1996, 059902, section 2.4.4). The risk equation(s) for the forward calculation(s) uses the models and parameter values developed for the residential, industrial, construction worker, and recreational SSLs (NMED 2006, 092513, or latest version; EPA 2006, 094321, or latest version; LANL 2007, 094496, or latest version). The exposure and chemical-specific parameter values cited in the appropriate guidance (NMED 2006, 092513, or latest version; EPA 2006, 094321, or latest version; LANL 2007, 094496, or latest version) are applied in an analogous manner as in the calculation of the SSL (see Appendix B for example table).

3.3.2 Inhalation—Fugitive Dust

The concentration of dust in air above contaminated soils and sediment is calculated using a screening-level soil resuspension model, EPA's particulate emission factor (PEF) model. This model originally was described in "Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites" (EPA 1985, 059903). The version of the PEF model used for calculating SSLs is consistent with NMED guidance (NMED 2006, 092513, or latest version) and is presented in the user's guide and technical background document of EPA's soil-screening guidance documents (EPA 1996, 058917; EPA 1996, 059902). The primary difference between the two versions of the PEF model is that the output of a separate air-dispersion model (based on 1 yr of meteorological data) has replaced the earlier box-model component. From a table of dispersion model output ordered by area and regional location, users select a value most applicable to the site under consideration for their assessment.

The PEF model used for screening the dust inhalation pathway under the residential, industrial, and recreational scenarios is based on wind erosion of surfaces with an unlimited reservoir of particles. The model calculates the concentration of respirable particles in the air from wind erosion. Depending on soil conditions at the site, an unlimited supply of particles of this size may not be available throughout the exposure period, which may overestimate the intake through dust inhalation. The model does not address particulate resuspension caused by vehicular traffic. Therefore, fugitive dust concentrations calculated using this model are not applicable for activities such as construction. For a construction worker scenario, the PEF considers windborne dust emissions and vehicular traffic emissions associated with construction activities.

The PEF model equations and parameter values for SSL calculations are documented in section 3.4, Soil Screening Level Equations and Parameter Values. Parameter values for the PEF model, including the dispersion term (Q/C), vegetative cover, and wind speeds are recommended in NMED soil-screening guidance (NMED 2006, 092513, or latest version).

3.3.3 Dermal Absorption

The amount of soil residing on a unit area of skin is described using an adherence factor (AF). A layer of soil is assumed to cover 100% of a specified body surface area corresponding to the AF. The AFs are dependent upon body part, soil type, particle size, soil moisture content, and other variables. Because information for quantifying these variables often is not available, single default values are used for the AFs when SSLs are calculated (0.2 mg/cm^2 for a child and adult worker, 0.3 mg/cm^2 for a construction worker, and 0.07 mg/cm^2 for an adult resident and recreational user) (NMED 2006, 092513, or latest version).

Dermal absorption from soil is evaluated using a skin absorption factor (ABS) to model desorption of a chemical from soil, absorption through skin, and transfer to the bloodstream. According to NMED soil-screening guidelines (NMED 2006, 092513, or latest version), a default ABS value for semivolatile organic chemicals is 0.1 (EPA 2004, 090800); no ABS is available for inorganic chemicals and VOCs. Chemical-specific ABS values obtained from EPA Region 6 guidance (EPA 2006, 094321, or latest version) are used in SSL calculations for the following chemicals: arsenic (0.03); cadmium (0.01); chlordane (0.04); 2,4-dichlorophenoxyacetic acid (2,4-D) (0.05); p',p'-dichlorodiphenyltrichloroethane/ p',p'-dichlorodiphenyldichloroethylene/p',p'-dichlorodiphenyldichloroethane (DDT/DDD/DDE) (0.03); hexachlorocyclohexane (lindane) (0.04); 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (0.03); polyaromatic hydrocarbons (0.13); polychlorinated biphenyls (0.14); and pentachlorophenol (0.25).

The approach used to model dermal absorption incorporates several conservative assumptions that may overestimate actual absorption. The ABS value reflects an assumption that absorption is independent of concentration and does not change with time. A chemical is assumed to be 100% available for absorption from soil adhered to the skin.

The dermal absorption pathway also includes assumptions that may over- or underestimate absorption. As described in section 3.1, oral toxicity values are not corrected for GI absorption efficiency, resulting in the potential for over- or underestimating risk through the dermal pathway. An additional assumption is that skin is presumed to be intact; abrasions or cuts on the skin surface that could result in greater absorption on an individual basis are not considered. These two assumptions, which may underestimate dermal risk, are balanced by the conservative assumptions already discussed in this section and do not compromise the protective quality of SSLs.

3.4 Soil Screening Level Equations and Parameter Values

Equations 1 and 2 are used to calculate residential and recreational user SSLs for noncarcinogenic and carcinogenic chemicals, respectively, through direct soil ingestion, inhalation of chemical vapors or airborne dust, and dermal absorption from soil. Table 1 gives parameters for these equations (see Appendix B for example tables for the risk assessment).

Combined Exposures for Noncarcinogenic Chemicals in Soil

$$C(\text{mg/kg}) = \frac{THQ \times BW_c \times AT_n}{EF \times ED_c \times \left[\left(\frac{1}{RfD_o} \times \frac{IRS_c}{10^6\,\text{mg/kg}}\right) + \left(\frac{1}{RfD_o} \times \frac{SA_c \times AF_c \times ABS}{10^6\,\text{mg/kg}}\right) + \left(\frac{1}{RfD_i} \times \frac{IRA_c}{(VF_s \text{ or } PEF)}\right)\right]}$$ **Equation 1**

Note: Use VF_s for volatile chemicals and PEF for nonvolatile chemicals.

Combined Exposures for Carcinogenic Chemicals in Soil

$$C(\text{mg/kg}) = \frac{TR \times AT_c}{EF \times \left[\left(\frac{IFS_{adj} \times CSF_o}{10^6\,\text{mg/kg}}\right) + \left(\frac{SFS_{adj} \times ABS \times CSF_o}{10^6\,\text{mg/kg}}\right) + \left(\frac{InhF_{adj} \times CSF_i}{(VF_s \text{ or } PEF)}\right)\right]}$$ **Equation 2**

Note: Use VF_S for volatile chemicals and PEF for nonvolatile chemicals.

Table 1
Parameters Used in the SSL Equations

Symbol	Definition	Residential Values	Recreational User Values	Industrial Worker Values	Co
C	Scenario-specific chemical SSL in soil (mg/kg)				
THQ	Target hazard quotient	1	1	1	1
TR	Target cancer risk	10^{-5}	10^{-5}	10^{-5}	10
AT_c	Averaging time (carcinogen)	70 yr × 365 days	70 yr × 365 days	70 yr × 365 days	70
AT_n	Averaging time (noncarcinogen)	ED × 365 days	ED × 365 days	ED × 365 days	ED
ABS	Skin absorption factor	Semivolatile organic compounds = 0.1	Semivolatile organic compounds = 0.1	Semivolatile organic compounds = 0.1	Se co
		Chemical-specific (section 3.3.3)	Chemical-specific (section 3.3.3)	Chemical-specific (section 3.3.3)	Ch (se
AF_c	Adherence factor–child	0.2 mg/cm^2	0.2 mg/cm^2	n/a[a]	n/a
BW_c	Body weight–child	15 kg (0–6 yr of age)	31 kg (6–11 yr of age)	n/a	n/a
CSF_o	Cancer slope factor–oral (chemical-specific)	(mg/kg-day)$^{-1}$ (see section 3.1)	(mg/kg-day)$^{-1}$ (see section 3.1)	(mg/kg-day)$^{-1}$ (see section 3.1)	(m (se
CSF_i	Cancer slope factor–inhalation (chemical-specific)	(mg/kg-day)$^{-1}$ (see section 3.1)	(mg/kg-day)$^{-1}$ (see section 3.1)	(mg/kg-day)$^{-1}$ (see section 3.1)	(m se
EF	Exposure frequency	350 day/yr	200 events/yr	225 day/yr	25
ED_c	Exposure duration–child	6 yr (0–6 yr of age)	6 yr (6–11 yr of age)	n/a	n/a
IFS_{adj}	Age-adjusted ingestion factor	114 mg-yr/kg-day	22.6 mg-yr/kg-day	n/a	n/a
$InhF_{adj}$	Age-adjusted inhalation factor	11 m^3-yr/kg-day	0.8 m^3-yr/kg-day	n/a	n/a
IRA_c	Inhalation rate–child	10 m^3/day	1.2 m^3/hr	n/a	n/a
IRS_c	Soil ingestion rate–child	200 mg/day	71.4 mg/day (400 mg/day × 1 h/5.6 h)[b]	n/a	n/a
PEF	Particulate emission factor	6.61 × 10^9 m^3/kg	6.61 × 10^9 m^3/kg	6.61 ×10^9 m^3/kg	2.

Table 1 (continued)

Symbol	Definition	Residential Values	Recreational User Values	Industrial Worker Values	C
RfD_o	Reference dose–oral (chemical-specific)	(mg/kg-day) (see section 3.1)	(mg/kg-day) (see section 3.1)	(mg/kg-day) (see section 3.1)	(n (s
RfD_i	Reference dose–inhalation (chemical-specific)	(mg/kg-day) (see section 3.1)	(mg/kg-day) (see section 3.1)	(mg/kg-day) (see section 3.1)	(n (s
SA_c	Exposed surface area–child	2800 cm^2/day (head, hands, forearms, lower legs, feet)	3525 cm^2/day (head, hands, forearms, lower legs, feet)	n/a	n/
SFS_{adj}	Age-adjusted skin contact factor for carcinogens	361 mg-yr/kg-day	273.3 mg-yr/kg-day	n/a	n/
VF_s	Volatilization factor for soil (chemical-specific)	(m^3/kg) (see below)	(m^3/kg) (see below)	(m^3/kg) (see below)	(n
BW_a	Body weight–adult	70 kg	70 kg	70 kg	7(
ED	Exposure duration	30 yr[c]	30 yr[c]	25	1
AF_a	Adherence factor–adult	0.07 mg/cm^2	0.07 mg/cm^2	0.2 mg/cm^2	0.
IRS_a	Soil ingestion rate–adult	100 mg/day	25.6 mg/day (100 mg/day × 1 hr/3.9 hr)[d]	100 mg/day	3
SA_a	Exposed surface area–adult	5700 cm^2/day (head, hands, forearms, lower legs)	5700 cm^2/day (head, hands, forearms, lower legs)	3300 cm^2/day (head, hands, forearms)	3 ha
IRA_a	Inhalation rate–adult	20 m^3/day	1.6 m^3/hr	20 m^3/day	2(

[a] n/a = Not applicable.

[b] Assumes 1 hr of use per day, with potential exposure to contaminants occurring over all of that time out of an average of 5.6 hr spent outdoors per day Table 15-176, p. 15-187).

[c] Exposure duration for lifetime resident is 30 yr. For carcinogens, the exposures are combined for child (6 yr) and adult (24 yr).

[d] Assumes 1 hr of trail use per day, with potential exposure to contaminants occurring over all of that time out of an average of 3.9 hr spent outdoors per Table 15-10, pp. 15-28 and 15-29).

Because contact rates may be different for children and adults, carcinogenic risks during the first 30 yr of life are calculated using age-adjusted factors ("adj"). Use of age-adjusted factors is especially important for soil ingestion exposures, which are higher during childhood and decrease with age. However, for purposes of combining exposures across pathways, additional age-adjusted factors are used for inhalation and dermal exposures. Under site-specific conditions (e.g., if the area is within Laboratory property) either an adult trail user or a child under the extended backyard scenario may be appropriate. If such conditions apply to a site, SSLs may be calculated for the individual receptor with justification. Appendix D presents the recreational SSLs for carcinogenic and noncarcinogenic chemicals.

Equation 3 is used (mg-yr)/(kg-day) for ingestion:

$$\mathrm{IFS_{adj}} = \frac{\mathrm{ED_c} \times \mathrm{IRS_c}}{\mathrm{BW_c}} + \frac{(\mathrm{ED} - \mathrm{ED_c}) \times \mathrm{IRS_a}}{\mathrm{BW_a}}$$ **Equation 3**

Equation 4 is used (mg-yr)/(kg-day) for dermal contact:

$$\mathrm{SFS_{adj}} = \frac{\mathrm{ED_c} \times \mathrm{AF_c} \times \mathrm{SA_c}}{\mathrm{BW_c}} + \frac{[(\mathrm{ED} - \mathrm{ED_c}) \times \mathrm{AF_a} \times \mathrm{SA_a}]}{\mathrm{BW_a}}$$ **Equation 4**

Equation 5 is used (m^3-yr)/(kg-day) for inhalation:

$$\mathrm{InhF_{adj}} = \frac{\mathrm{ED_c} \times \mathrm{IRA_c}}{\mathrm{BW_c}} + \frac{[(\mathrm{ED} - \mathrm{ED_c}) \times \mathrm{IRA_a}]}{\mathrm{BW_a}}$$ **Equation 5**

For the industrial or construction worker exposure scenario, an adult worker is the receptor, and the equations used to calculate SSLs for noncarcinogenic and carcinogen chemicals, respectively, through direct soil ingestion, inhalation of chemical vapors or airborne dust, and dermal absorption from soil are presented in Equations 6 and 7. The parameter values for the industrial and construction worker exposures are presented in Table 1.

$$C(mg/kg) = \frac{TR \times BW_a \times AT_c}{EF \times ED\left[\left(\frac{IRS_a \times CSF_o}{10^6 mg/kg}\right) + \left(\frac{SA_a \times AF_a \times ABS \times CSF_o}{10^6 mg/kg}\right) + \left(\frac{IRA_a \times CSF_i}{VF_s}\right)\right]}$$ **Equation 6**

$$C(mg/kg) = \frac{THQ \times BW_a \times AT_n}{EF \times ED\left[\left(\frac{1}{\mathrm{RfD_o}} \times \frac{\mathrm{IRS_c}}{10^6 \mathrm{mg/kg}}\right) + \left(\frac{SA_a \times AF_c \times ABS}{10^6 mg/kg}\right) + \left(\frac{1}{\mathrm{RfD_i}} \times \frac{IRA_a}{\mathrm{VF_s \, or PEF}}\right)\right]}$$ **Equation 7**

Derivation of the VF

Equation 8 is used to derive the VF for VOCs used to calculate SSLs; the parameters are presented in Table 2.

$$VF_s = \left(\frac{Q}{C}\right) \times \frac{(3.14 \times D_A \times T)^{1/2}}{2 \times \rho_b \times D_A} \times 10^{-4} \left(m^2/cm^2\right) \qquad \textbf{Equation 8}$$

Where $D_A = \dfrac{\left(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w\right)/n^2}{\rho_b K_d + \Theta_w + \Theta_a H'}$

Derivation of the Soil Saturation Concentration (C_{sat})

Equation 9 is used to derive the C_{sat} for organic chemicals; the parameters are presented in Table 3.

$$C_{sat} = \frac{S}{\rho_b}\left(K_d \rho_b + \Theta_w + H' \Theta_a\right) \qquad \textbf{Equation 9}$$

Parameter values used in calculating the VF and C_{sat} for site-related factors such as soil porosities, density, and amount of organic carbon and chemical-specific parameter values such as chemical diffusivity in air and water, Henry's Law constant, solubility in water, and organic carbon partition coefficient are presented in NMED guidance (NMED 2006, 092513, or latest version). The sources used to obtain these values, in order of priority, are (1) EPA's soil-screening guidance (EPA 1996, 058917; EPA 1996, 059902) and (2) EPA's Superfund chemical data matrix (EPA 1996, 064708). Other references that may be used if data are unavailable in the primary references include the *Handbook of Environmental Fate and Exposure Data for Organic Chemicals* (Howard 1990, 059892); EPA's subsurface contamination reference guide (EPA 1990, 059926); and EPA's Superfund exposure assessment manual (EPA 1988, 059901).

Derivation of the PEF

Equation 10 is used to derive the PEF for windborne emissions for non-VOCs and inorganic chemicals for use in the calculation of SSLs. The parameters are presented in Table 4 and are obtained from NMED guidance (NMED 2006, 092513, or latest version).

$$PEF = \frac{Q}{C} \times \frac{3{,}600 \text{sec/h}}{0.036 \times (1 - V) \times (U_m/U_t)^3 \times F(x)} \qquad \textbf{Equation 10}$$

Equation 11 is used to derive the PEF for windborne dust as well as vehicular emissions for nonvolatile organic chemicals and inorganic chemicals for calculating SSLs. The parameters are presented in Table 5 and are obtained from NMED guidance (NMED 2006, 092513, or latest version).

$$PEF_{cw} = \frac{Q}{C_{cw}} \times 1/F_D \left[\frac{T \times A_R}{556 \times (W/3)^{0.4} \times (365 \text{ days/yr} - P) \div 365 \text{ days/yr} \times \sum VKT}\right] \qquad \textbf{Equation 11}$$

4.0 DERIVATION OF SCREENING ACTION LEVELS FOR RADIOLOGICAL CHEMICALS

The SALs for radionuclides are based on dose and are calculated using the RESRAD computer code (*web.ead.anl.gov/resrad/home2/*). The dose limit used as the basis for radionuclide SALs at a site is 15 mrem/yr (DOE 2000, 067153). The exposure scenarios and receptors for radionuclides are the same as for chemicals: residential (child and adult), industrial and construction worker (adult), and recreational (child and adult).

Table 2
Parameters Used in the Derivation of VFs

Symbol	Definition	Values (Units)
VF_s	Volatilization factor	Chemical-specific (m^3/kg)
D_A	Apparent diffusivity	Chemical-specific (cm^2/sec)
Q/C	Inverse of mean concentration at the center of a 0.5-ac^2 source	68.18 (g/m^2–sec per kg/m^3)
T	Exposure interval	9.5×10^8 (sec)
ρ_b	Dry soil bulk density	1.5 (g/cm^3)
Θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.17
Θ_w	Water filled soil porosity (L_{water}/L_{soil})	0.26
D_i	Diffusivity in air	Chemical-specific (cm^2/sec)
H'	Dimensionless Henry's Law constant	Chemical-specific
D_w	Diffusivity in water	Chemical-specific (cm^2/sec)
n	Total soil porosity $1 - (\rho_b/\rho_s)$	0.43
ρ_s	Soil particle density	2.65 (g/cm^3)
K_d	Soil-water partition coefficient (K_{oc} x f_{oc})	Chemical-specific (cm^3/g)
K_{oc}	Soil organic carbon/water partition coefficient	Chemical-specific (L/kg)
f_{oc}	Fraction organic carbon content of soil	0.0015 (g/g)

Note: H' = Henry's Law Constant ÷ universal gas constant × temperature.

Table 3
Parameters Used in the Derivation of the Soil Saturation Concentration

Symbol	Definition	Values (Units)
C_{sat}	Soil saturation concentration	Chemical-specific (mg/kg)
S	Solubility in water	Chemical-specific (mg/L)
K_d	Soil-water partition coefficient (K_{oc} x f_{oc})	Chemical-specific (cm^3/g)
K_{oc}	Soil organic carbon/water partition coefficient	Chemical-specific (L/kg)
f_{oc}	Fraction organic carbon content of soil	0.0015 (g/g)
ρ_b	Dry soil bulk density	1.5 (g/cm^3)
Θ_w	Water filled soil porosity (L_{water}/L_{soil})	0.26
H'	Dimensionless Henry's Law constant	Chemical-specific
Θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.17

Note: H' = Henry's Law Constant ÷ universal gas constant × temperature.

Table 4
Parameters Used in the Derivation of the PEF for Residential, Industrial, and Recreational Exposures

Symbol	Definition	Values (Units)
PEF	Particulate emission factor	6.61×10^9 m^3/kg
Q/C	Inverse of the mean concentration at the center of a 0.5-ac^2 source	81.85 (g/m^2–sec per kg/m^3)
V	Fraction of vegetative cover	0.5 (unitless)
U_m	Mean annual wind speed	4.02 (m/sec)
U_t	Equivalent threshold value of wind speed at 7 m	11.32 (m/sec)
F(x)	Function dependent on U_m/U_t (derived using EPA 1985, 059903)	0.0553 (unitless)

Table 5
Parameters Used in the Derivation of the PEF for Construction Worker Exposure

Symbol	Definition	Values (Units)
PEF_{CW}	Particulate emission factor	2.1×10^6 (m^3/kg)
Q/C_{CW}	Inverse of the mean concentration at the center of a 0.5-ac^2 source	23.02 (g/m^2-sec per kg/m^3)
F_D	Dispersion correction factor	0.185 (unitless)
T	Total time over which construction occurs	7.2E+06 (seconds)
A_R	Surface area of road segment	274.2 (m^2)
W	Mean vehicle weight	8 (tons)
P	Number of days with at least 0.01 in. of precipitation	60 (days/yr)
Σ VKT	Sum of fleet vehicle kilometers traveled during the exposure duration	168.75 (km)

RESRAD incorporates the dose assessment methodology described in DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and is used to implement residual radioactive material guidelines contained in this DOE order. As stated in a DOE Albuquerque Operations Office (DOE-AL) memorandum regarding the release of real property with residual radioactive materials, "DOE requires the use of RESRAD computer models for evaluating potential doses resulting from the presence of residual contamination" (DOE 2000, 067153).

4.1 Target Dose Limit

DOE-AL has published guidance addressing the selection of annual dose limits for dose assessments under its jurisdiction: "DOE-AL staff will approve proposed releases of real property where the modeled dose is up to and including 15 mrem/yr. Proposed releases resulting in doses greater than 15 mrem/yr require concurrence with DOE-HQ" (DOE 2000, 067153). A 15-mrem/yr target dose limit is well below the basic dose limit of 100 mrem/yr above background established in DOE Order 5400.5. The SALs for radionuclides (residential, industrial, construction worker, and recreational) are presented in Appendix E. A detailed presentation and discussion of the derivation and use of radionuclide SALs are provided in LANL guidance (LANL 2005, 088493). Appendix B presents examples of the tables for the screening comparisons to be included in the risk assessment appendix.

As described in section 2.2.4, the DOE has an agreement in principal with NMED regarding risk from radionuclides. Per the agreement, the Laboratory provides the equivalent total radionuclide risk level for the decision scenario(s) for each site that is the subject of the environmental investigation. This information is also presented in the conclusion section of the investigation report.

4.2 Exposure Scenario, Media, and Pathways

The SALs used in the screening evaluation are based on the current and reasonably foreseeable future land use for the site; a residential exposure is protective of the other land-use options. Radionuclide SALs are designed to predict the maximal on-site soil dose over time and do not account for radionuclide migration with surface water and/or infiltration to groundwater. Radionuclide migration with water may be of equal or greater concern as soil dose at some canyon-bottom sites and at mesa-top sites where potentially contaminated water was discharged. Therefore, at these types of sites in particular, radionuclide SALs may need to be supplemented with an evaluation of migration potential.

The exposure pathways used to calculate radionuclide SALs are incidental soil ingestion, inhalation, external irradiation, and ingestion of homegrown produce (for a resident only). Unique exposure pathways for a gaseous form of tritium (as water vapor) include ambient inhalation of tritiated water vapor and absorption of tritiated water vapor through the skin. A unique exposure pathway for radon (resident only) is the inhalation of radon gas. Ingestion of homegrown produce is a commonly evaluated pathway in radionuclide dose assessments but generally is excluded in screening-level chemical risk assessment calculations (e.g., plant ingestion is not included in the soil-screening criteria published by NMED and EPA Regions 6 and 9). In keeping with common practice and because certain radionuclides (particularly strontium-90) known to occur at some sites are susceptible to plant uptake, ingestion of homegrown produce is included among the pathways used to calculate radionuclide SALs for a resident.

The primary sources of exposure parameters used in radionuclide SAL calculations are EPA's supplemental screening-level guidance (EPA 2001, 087462) and EPA's handbook of exposure factors (EPA 1997, 066596; EPA 1997, 066597; EPA 1997, 066598). The parameter values are intended to provide an estimate of the reasonable maximum exposure for the exposure scenario incorporating the pathways listed above (see Appendix B for example tables).

4.3 Key Input Parameters and Assumptions

To determine whether radionuclide SALs are applicable to a particular site, it is necessary to determine if the assumptions underlying their calculation are consistent with the CSM. This model includes what is known or assumed regarding the spatial distribution of radionuclides in soil, the potential for radionuclide migration over time, and the characteristics of the applicable receptor population. If potentially important site-specific transport or exposure pathways are not included in the derivation of the radionuclide SALs, a comparison of site data to radionuclide SALs either may be inappropriate or may require site-specific calculation of screening values representative of the site. If screening is determined to be inappropriate for a site, a site-specific dose assessment is conducted.

Radionuclide migration from a contaminated site may occur by dissolution in surface or groundwater, erosion of soil, resuspension as airborne particulate, biotic uptake, and/or volatilization as a vapor. Radionuclide migration to an off-site location is not incorporated in the calculation of radionuclide SALs, nor does RESRAD directly support such evaluations. Although potential off-site radionuclide concentrations are generally lower than those observed on the site, modeling remote concentrations over time may be important because of (1) public concerns, (2) different routes and/or intensities of exposure than are considered for on-site receptors, and (3) regulatory requirements to assess off-site impacts. An

example of a potentially substantial off-site impact is the uptake of strontium-90 by plants rooted in contaminated soil and the subsequent redistribution in leaf litter or in fine particulates if the plant or plant material burns. Appendix K of Yu et al. (2001, 071420) provides guidance for evaluating off-site migration using RESRAD output.

Certain parameters are critical to defining site conditions and ascertaining possible changes of these conditions over time. These parameters generally are subject to great site-specific variability, such as the size, thickness, and soil-erosion rate of the contaminated zone; the evapotranspiration coefficient at the site; and the site-related soil particulate concentration in air. In addition, the length of the modeling period can influence radionuclide SALs for certain radionuclides associated with ingrowth of radioactive progeny. These parameter values have been defined, and therefore the calculation of radionuclide SALs effectively results in static soil conditions (LANL 2005, 088493). As a result, radionuclides in soil are modeled so they do not leach from the contaminated zone or become depleted as a result of erosion. Table 6 presents the exposure input parameters to RESRAD to calculate SALs for each of the scenarios (i.e., residential, industrial, recreational, and construction worker).

Although the contaminated zone is modeled as static with respect to radionuclide loss through erosion and leaching, RESRAD accounts for radon and tritium diffusing as gases (lost to the atmosphere) from contaminated soil. As a result, the modeled tritium dose declines rapidly over time. Radon isotopes, however, will be in equilibrium with their parent nuclides; changes over time for dose rates through radon inhalation will depend on site-specific conditions with respect to the concentrations of these parent nuclides. Radon dose rates also can be influenced by many radon pathway-specific parameters that govern the diffusion of radon through soil and into a building (fraction of time indoors applies to a resident only, see Table 6). Tritium diffusion from soil as water vapor (resulting in the inhalation dose) is greatly affected by the absolute humidity of the air above the contaminated zone (a local value for absolute humidity is used in radionuclide SAL calculations) (LANL 2005, 088493).

5.0 EVALUATION OF COPCS RETAINED BY THE SCREENING ASSESSMENT

If the screening assessment demonstrates acceptable risk or dose, the site needs no further evaluation for potential risk to human health. If a potential unacceptable risk or dose based on the screening assessment exists, a risk-management decision must be made whether to conduct a baseline risk assessment, proceed with an accelerated action, or initiate a CME of the site. All COPCs identified and retained by the screening assessment are carried forward for further evaluation. Chemicals and radionuclides screened out using SSLs/SALs or otherwise eliminated in the screening assessment may be excluded from the site-specific risk assessment. This course of action is appropriate if it is apparent from the screening assessment that chemicals and radionuclides eliminated by this process contribute only negligible risks/doses in a baseline assessment (i.e., less than 10% of the total risk, hazard, and/or dose). These chemicals and radionuclides are discussed in the uncertainty section of the risk assessment. In other cases, chemicals and radionuclides may be present slightly below their SSLs/SALs, in which case it may be prudent to include them in a baseline risk assessment.

Table 6
RESRAD Parameters for Calculating Radionuclide SALs

Parameter	Units	Resident[a]	Industrial Worker[b]	Recreational User[b]	Construction Worker[b]
Radiation dose limit	mrem/yr	15	15	15	15
Area of contaminated zone	m^2	10000	10000	10000	10000
Thickness of contaminated zone	m	2	2	2	2
Length parallel to aquifer flow	m	100	—[c]	—	—
Time since placement of material	yr	0	0	0	0
Cover depth	m	0	0	0	0
Density of contaminated zone	g/m^3	1.5	1.5	1.5	1.5
Contaminated zone erosion rate	m/yr	0	0	0	0
Contaminated zone total porosity	—	0.43	0.43	0.43	0.43
Contaminated zone effective porosity	—	0.2	0.2	0.2	0.2
Contaminated zone hydraulic conductivity	m/yr	10	10	10	10
Contaminated zone b parameter	—	5.3	5.3	5.3	5.3
Humidity in air	g/m^3	5.55	5.55	5.55	5.55
Evapotranspiration coefficient[d]	—	0.999	0.999	0.999	0.99
Precipitation	m/yr	0.48	0.48	0.48	0.48
Runoff coefficient	—	0.9	0.9	0.9	0.9
Watershed area	m^2	1,000,000	—	—	—
Inhalation rate	m^3/yr	3652	19481	10526[e]	19478
Mass loading for inhalation	g/m^3	0.00000015	0.00000015	0.00000015[e]	0.0004
Exposure duration	yr	6	25	6[e]	1
Fraction of time spent indoors each year	—	0.735	0.0	—	0
Fraction of time spent outdoors	—	0.224	0.2053	0.023	0.257
Shape factor, external gamma	—	1	1	1	1
Fruits, vegetables, and grain consumption	kg/yr	57	—	—	—
Mass loading for foliar deposition	g/m^3	0.0001	—	—	—
Soil ingestion rate	g/yr	73	97.4	626[e]	321
Wet weight crop yield for nonleafy vegetation	kg/m	0.7	—	—	—
Wet weight crop yield for leafy vegetation	kg/m	1.5	—	—	—
Growing season for nonleafy vegetation	yr	0.17	—	—	—
Growing season for leafy vegetation	yr	0.25	—	—	—
Translocation factor for nonleafy vegetation	—	0.1	—	—	—
Translocation factor for leafy vegetation	—	1	—	—	—
Dry foliar interception fraction for nonleafy vegetation	—	0.25	—	—	—
Dry foliar interception fraction for leafy vegetation	—	0.25	—	—	—
Wet foliar interception fraction for nonleafy vegetation	—	0.25	—	—	—

Table 6 (continued)

Parameter	Units	Resident[a]	Industrial Worker[b]	Recreational User[b]	Construction Worker[b]
Wet foliar interception fraction for leafy vegetation	—	0.25	—	—	—
Weathering removal constant for vegetation	—	20	—	—	—

Note: Parameters not presented here use default values for RESRAD.

[a] Pathways evaluated include soil ingestion, dust inhalation, plant ingestion, radon inhalation, and external gamma.

[b] Pathways evaluated include soil ingestion, dust inhalation, radon inhalation, and external gamma.

[c] — = Not applicable.

[d] No infiltration is predicted because the evapotranspiration coefficient is >1; therefore, the hydrogeological parameters that follow have no impact on dose rates.

[e] Parameters are for the child trail user (extended backyard): inhalation rate of 10526 m^3/yr (1.2 m^3/hr × 200 hr/yr ÷ 0.023), calculated as (1÷ 6.6 × 10^9 m^3/kg) × 1000 g/kg, 6 yr duration for child exposure (6–11 yr of age), and soil-ingestion rate of 626 g/yr [(0.4 g/day ÷ 5.6 hr/day) × 200 hr/yr ÷ 0.023 site occupancy].

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Appendix A

Risk Assessment Report Format

The following format requirements are adapted from the Compliance Order on Consent signed on March 1, 2005.

The Respondents shall prepare risk assessment reports for sites requiring corrective action at the Facility using the format listed below. This section provides a general outline for risk assessments and also lists the minimum requirements for describing risk assessment elements. In general, interpretation of data shall be presented only in the Background, Conceptual Site Model, and Conclusions and Recommendations sections of the reports. The other text sections of the Risk Assessment report shall be reserved for presentation of sampling results from all investigations, conceptual and mathematical elements of the risk assessment, and presentations of toxicity information and screening values used in the risk assessment. Risk assessment results are presented in separate sections of the report for the human health and ecological risk assessments, but the general risk assessment outline applicable to both sections is provided below.

Title Page

The title page shall include the type of document; Facility name; technical area (TA) designation; solid waste management unit (SWMU) or area of concern (AOC) name, site, and any other unit name; and the submittal date. A signature block providing spaces for the name and title of the responsible Department of Energy and University of California (or co-operator) representative shall be provided on the title page in accordance with 20.4.1.900 New Mexico Administrative Code (NMAC) incorporating 40 CFR 270.11(d)(1).

Executive Summary (Abstract)

The executive summary or abstract section shall provide a brief summary of the purpose and scope of the risk assessment of the subject site. The Executive Summary shall also briefly summarize the conclusions of the risk assessment. The Facility, SWMU, AOC, and site names, location, and TA designation shall be included in the executive summary.

Table of Contents

The table of contents shall list all text sections, subsections, tables, figures, and appendixes or attachments included in the risk assessment. The corresponding page numbers for the titles of each unit of the report shall be included in the table of contents.

Introduction

The introduction section shall include the Facility name, TA designation, unit location, and unit status (e.g., closed, corrective action). General information on the current site usage and status shall be included in this section.

Background

The background section shall describe relevant background information. This section shall briefly summarize historical site uses by the U.S. Government and any other entity since 1940, including the locations of current and former site structures and features. A labeled figure shall be included in the document showing the locations of current and former site structures and features.

Site Description

A section shall describe current site topography, features and structures including topographic drainages, man-made drainages, erosion features, current site uses, and other data relevant to assessing risk at the site. Depth to groundwater and direction of groundwater flow shall be included in this section. The presence and location of surface water bodies such as springs or wetlands shall be noted in this section. Photographs of the site may be incorporated into this section. Ecological features of the site shall be described here, including type and amount of vegetative cover, observed and expected wildlife receptors, and level of disturbance of the site. The Los Alamos National Laboratory (LANL) ecological checklist for the site may be included as an appendix or attachment to the document and its inclusion may meet the requirement to describe the ecological features of the site. A topographical map of the site and vicinity of the site showing habitat types, boundaries of each habitat, and any surface water features shall be included in the Figures section of the document.

Sampling Results

A section shall discuss the results of the sampling at the site. It shall include a description of the history of releases of contaminants, the known and possible sources of contamination, and the vertical and lateral extent of contamination present in each medium. This section shall include summaries of sampling results of all investigations including site plans (included in the Figures section of the report) showing locations of detected contaminants. This section shall reference pertinent figures, data summary tables, and references in previous reports. References to previous reports shall include page, table, and figure numbers for referenced information. Summaries of sampling data shall include for each constituent: the maximum value detected, the detection limit, the 95 percent upper confidence level (UCL) of the mean value detected (if applicable to the data set), and whether the 95 percent UCL of the mean was calculated based on a normal or lognormal distribution. Background values used for comparison to inorganic constituents at the site shall be presented here. The table of background values should appear in the Tables section of the document and include actual values used as well as the origin of the values (e.g., Facility-wide, UCL, upper tolerance level [UTL]). This section shall also include a discussion of how "nondetect" sample results were handled in the averaging of data.

Conceptual Site Model

A section shall present the conceptual site model. It shall include information on the expected fate and transport of contaminants detected at the site. This section shall provide a list of all sources of contamination at the site. Sources no longer considered to be ongoing but represent the point of origination for contaminants transported to other locations shall be included. The discussion of fate and transport shall address potential migration of each contaminant in each medium, potential breakdown products and their migration, and anticipated pathways of exposure for human or ecological receptors. Diagrammatic representations of the conceptual site model shall appear in the Figures section of the document.

For human health risk assessments, the conceptual site model shall include the current and reasonably foreseeable land use and residential land use for all risk assessments. All values for exposure parameters and the source of those values shall be included in table format and presented in the Tables section of the document.

Conceptual site models presented for ecological risk assessments shall identify assessment endpoints and measurement receptors for the site. The discussion of the model shall explain how the measurement

receptors for the site are protective of the wildlife receptors identified by the Respondents in the Site Description section.

Risk Screening Levels

A section shall present the actual screening values used for each contaminant for comparison to all human health and ecological risk screening levels. The Department's soil screening levels (SSLs) for residential and industrial soil shall be used to screen soil for human health using EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume I, Part A, 1989.* For those contaminants not appearing on the Department's SSL table, the EPA Region 6 soil screening value adjusted to meet the Department's risk goal of 10^{-5} for total risk for carcinogens shall be used to screen the site for human health risks. Screening for ecological risk shall be conducted using the LANL ecological screening levels (ESLs) if the LANL ESLs have received written approval from the Department. If the ESLs have not been approved by the Department or the LANL ESLs database does not contain a screening value for the receptor or contaminant of concern, the Respondents shall use U.S. EPA's ECO-SSLs, or derive a screening level using the methodology in the Department's "*Guidance for Assessing Ecological Risks Posed by Chemicals: Screening –Level Ecological Risk Assessment*" or in LANL's *"Screening Level Ecological Risk Assessment Methods* (LA-UR-99-1405.) If no valid toxicological studies exist for a particular receptor or contaminant, the contaminant/receptor combination shall be addressed using qualitative methods. If a Department-approved site-specific risk scenario is used for the human health risk assessment, this section shall include all toxicity information and exposure assessment equations used for the site-specific scenario as well as the sources for that information. Other regulatory levels applicable to screening the site, such as drinking water maximum contaminant levels (MCLs), shall also be included in this section.

Risk Assessment Results

A section shall present all risk values, hazard quotients (HQs), and hazard indexes (HIs) for human health based on current and reasonably foreseeable future land use. Where the current or reasonably future land use is not residential, risk values, HQs, and HIs for a residential land-use scenario shall also be calculated and reported. The residential scenario shall be used for comparison purposes only, unless the land use becomes residential. This section shall also present the HQ and HI for each contaminant for each ecological receptor.

Uncertainty Analysis

A section shall include discussion of qualitative, semi-quantitative, and quantitative uncertainty in the risk assessment and estimate the potential impact of the various uncertainties.

Conclusions and Recommendations

A section shall include the interpretation of the results of the risk assessment and any recommendations for future disposition of the site. This section may include additional information and considerations that the Respondents believe are relevant to the analysis of the site.

Tables

A section shall provide the following summary tables, as appropriate. With prior approval from the Department, the Respondents may combine one or more of the tables. Data presented in the summary tables shall include information on detection limits and significant data quality exceptions. The analytical

data tables shall include only detected analytes and data quality exceptions that could potentially mask detections.

1. A table presenting background values used for comparison to inorganic constituents at the site. The table shall include actual values used as well as the origin of the values (Facility-wide, UCL, UTL, or maximum).
2. A table summarizing sampling data shall include, for each constituent, all detected values above background, the maximum value detected, the 95 percent UCL of the mean value detected (if applicable to the data set), and whether that 95 percent UCL of the mean was calculated based on a normal or lognormal distribution.
3. A table of all screening values used and the sources of those values.
4. A table presenting all risk values, HQs, and HIs under current and reasonably foreseeable future land use for human health.
5. If residential use is not a current or reasonably foreseeable future land use, a table presenting all risk values, HQs, and HIs under a residential land-use scenario for human health shall be included for comparison purposes.
6. A table presenting the HQ and HI for each contaminant for each ecological receptor.
7. A table presenting values for exposure parameters and the sources of the values.

Figures

A section shall present the following figures for each site, as appropriate. With prior approval from the Department, the Respondents may combine one or more of the figures. All figures shall include an accurate bar scale and a north arrow. An explanation shall be provided on each figure for all abbreviations, symbols, acronyms, and qualifiers.

1. A vicinity map showing topography and the general location of the subject site relative to surrounding features or properties.
2. For human health risk assessments, a site plan that presents pertinent site features and structures, underground utilities, well locations, and remediation system location(s) and its details. Off-site well locations and other relevant features shall be included on the site plan if practical. Additional site plans may be required to present the locations of relevant off-site well locations, structures, and features.
3. For ecological risk assessments, a topographical map of the site and vicinity of the site showing the habitat types, the boundaries of each habitat, and any surface water features.
4. Conceptual site model diagrams for both human health and ecological risk assessments.

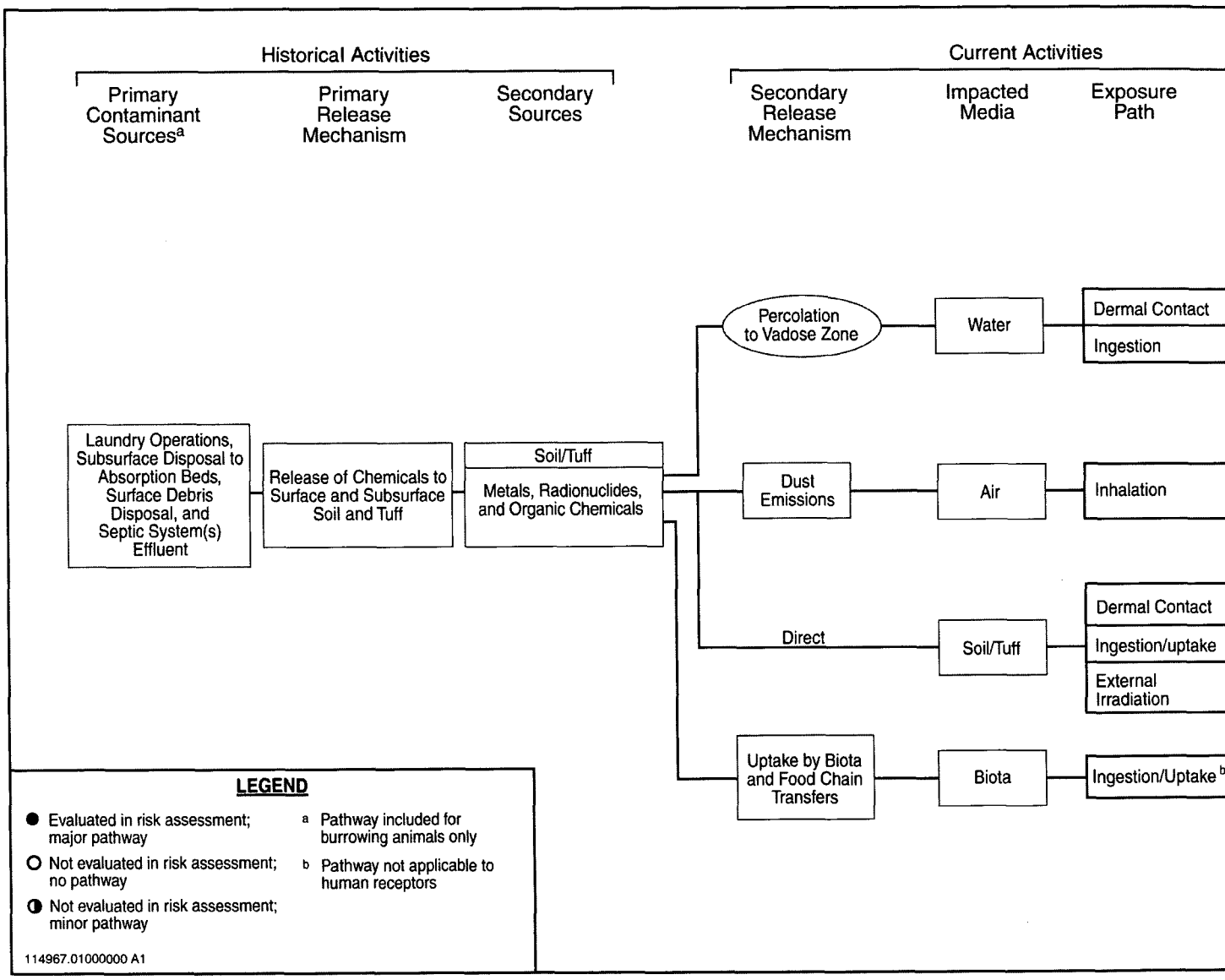
Appendixes

Each risk assessment report shall include appendixes containing supporting data. Appendixes may include the results of statistical analyses of data sets and comparisons of data, LANL ecological checklists for the site, full sets of results of all sampling investigations at the site, or other data as appropriate.

Appendix B

Example Figure and Tables for the Risk Assessment

The figure and tables presented in this appendix are examples of the format and presentation of the necessary information provided in the risk appendix. (Complete examples of the risk appendixes included in submitted investigation reports are available from the Risk Assessment Project Leader and on the Environmental Remediation and Support Services web page.) The examples are taken from previous risk assessment appendixes submitted to the New Mexico Environment Department for review and approval (as of December 31, 2006, only the Material Disposal Area U investigation report has been approved). The figure and tables are to be used as consistently as possible in the investigation report risk appendix. The figure of the conceptual site model is an example of the illustration to be provided to show the potential transport and exposure pathways as well as the receptors for the site being evaluated. It is not intended to be the only way to present this information (although consistency is encouraged). The tables presented are to be used in all reports as appropriate (e.g., if dioxins and furans were not analyzed, the table is not included). Deviations must be discussed with the Risk Assessment Project Leader before the peer review process begins. *Note that the organization, content, language, etc. of the risk assessment appendix must be discussed with the Risk Assessment Project Leader before it is written and should be discussed again before the report is submitted for peer review.*



Sample Figure Conceptual site model for ...

Sample Table
Industrial COPC Statistics for SWMU/AOC/Consolidated Unit ...

COPC	Number of Analyses	Distribution Type	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Standard Deviation (mg/kg)	9
Inorganic Chemicals							
Arsenic	31	Normal	0.465	4.5	2.05	0.853	2.3
Barium	31	Normal	0.9	191	98.8	47.5	11
Beryllium	31	Nonparametric	0.15	124	4.65	22.2	22
Cadmium	31	Normal	0.15	1.1	0.617	0.269	0.6
Chromium	31	Normal	1.7	11.6	6.84	2.32	7.5
Cobalt	31	Normal	0.455	8	4.27	2.01	4.8
Copper	31	Normal	2.31	8.1	5.07	1.44	5.5
Iron	31	Normal	3690	1570	8915	3057	98
Lead	31	Normal	6.1	18.8	12.05	2.81	12
Lithium	27	Gamma	2.7	14.8	6.96	3.02	8.0
Mercury	4	Normal	0.0065	0.022	0.012	0.0069	0.0
Nickel	31	Normal	0.75	10.8	5.82	2.31	6.5
Perchlorate	4	Nonparametric	0.0011	0.0022	0.0014	0.00054	0.0
Selenium	31	Nonparametric	0.17	0.825	0.307	0.199	0.3
Strontium	27	Normal	2.5	32.6	20.2	7.28	22
Thallium	31	Nonparametric	0.093	0.147	0.113	0.0078	0.1
Zinc	31	Nonparametric	22.9	132	39.4	22.4	46
Semivolatile Organic Compounds							
Benzo(a)anthracene	30	Nonparametric	0.018	0.36	0.164	0.067	0.2
Benzo(a)pyrene	30	Nonparametric	0.03	0.36	0.179	0.064	0.1
Benzo(b)fluoranthene	30	Nonparametric	0.015	0.36	0.177	0.068	0.2
Benzo(k)fluoranthene	30	Nonparametric	0.018	0.36	0.167	0.079	0.2
Benzoic acid	30	Nonparametric	0.294	1.8	0.932	0.309	1.0

Sample Table (continued)

COPC	Number of Analyses	Distribution Type	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Mean Concentration (mg/kg)	Standard Deviation (mg/kg)	95 (
Bis(2-ethylhexyl)phthathate	30	Gamma	0.044	0.36	0.108	0.078	0.1
Chrysene	30	Nonparametric	0.011	0.36	0.163	0.066	0.2
Di-n-butylphthalate	30	Nonparametric	0.175	0.695	0.213	0.101	0.2
Fluoranthene	30	Nonparametric	0.023	0.36	0.170	0.076	0.2
Indeno(1,2,3,-cd)pyrene	30	Nonparametric	0.018	0.36	0.179	0.067	0.2
Phenanthrene	30	Nonparametric	0.011	0.36	0.165	0.066	0.2
Pyrene	30	Nonparametric	0.018	0.36	0.166	0.068	0.2
Radionuclides (pCi/g)							
Americium-241	30	Nonparametric	0.005	34.8	4.57	8.48	11.
Cesium -137	4	n/a[a]	0.061	8.45	2.18	4.18	8.4
Plutonium-238	30	Nonparametric	0.002	6.85	0.765	1.77	2.1
Plutonium-239	30	Nonparametric	0.005	201	9.63	36.5	38.
Strontium-90	31	Nonparametric	-0.49	5.04	0.116	0.951	0.8
Uranium-234	30	Nonparametric	0.799	3.36	1.39	0.48	1.5
Uranium-235	30	Nonparametric	0.041	0.38	0.102	0.06	0.1
Uranium-238	30	Normal	0.871	1.56	1.23	0.167	1.2

[a] n/a = Not applicable (too few samples to calculate a distribution or 95% UCL).

[b] Maximum detected concentration used as the EPC.

Sample Table
K_d Values for Inorganic COPCs at ...

COPCs	K_d[a] (cm^3/g)
Arsenic	29
Chromium[b]	1800000
Lead	900
Uranium	na[c]
Aluminum	1500
Antimony	45
Barium	41
Cadmium	75
Cobalt	45
Copper	35
Mercury	52
Nickel	65
Nitrate	0.0356
Selenium	5
Silver	8.3
Thallium	71
Zinc	62
Beryllium	790
Vanadium	1000

[a] K_d values from NMED (2006, 092513).

[b] K_d values for chromium(III), the predominant species for chromium, used.

[c] na = Not available.

Sample Table
K_d Values for Radionuclide COPCS at ...

COPCs	K_d* (cm^3/g)
Americium-241	8.2
Cesium-137	1000
Plutonium-238	4500
Plutonium-239	4500
Strontium-90	35
Uranium-234	0.4
Uranium-235	0.4
Radium-223	450
Radon-219	9.9
Thorium-227	20

*K_d values from EPA (1996, 064708).

Sample Table
Chemical Properties of Organic COPCs at ...

COPCs	K_{oc}[a] (cm^3/g)	Solubility[a] (mg/L)	Log K_{ow}[b] (unitless)
Benzo(a)anthracene	3.98E+05	9.40E-03	5.76E+00
Benzo(a)pyrene	1.02E+06	1.62E-03	6.13E+00
Benzo(b)fluoranthene	1.23E+06	1.50E-03	5.78E+00
Benzo(k)fluoranthene	1.23E+06	8.00E-04	6.11E+00
Dibenz(a,h)anthracene	3.80E+06	2.49E-03	6.54E+00
Dichlorobenzidine[3,3'-]	7.24E+02	3.11E+00	3.51E+00
Indeno(1,2,3-cd)pyrene	3.47E+06	2.20E-05	6.70E+00
Chrysene	3.98E+05	1.60E-03	5.81E+00
Acetone	5.80E-01	1.00E+06	–2.40E-01
Acenaphthene	4.90E+03	4.24E+00	3.92E+00
Anthracene	2.95E+04	4.34E-02	4.45E+00
Aroclor-1242	4.48E+04	2.77E-01	6.3E+00
Aroclor-1254	5.30E+05	2.77E-01	6.8E+00
Aroclor-1260	5.30E+05	2.77E-01	8.3E+00
Benzo(g,h,i)perylene	2.68E+06[b]	2.6E-04[b]	6.63E+00
Benzoic acid	1.449E+01[b]	3.4E+03[b]	1.87E+00
Butylbenzylphthalate	1.38E+04[c]	2.9E+00[c]	4.73E+00
Dibenzofuran	7.76E+03	3.10E+00	4.12E+00
Diethylphthalate	2.88E+02	1.08E+03	2.42E+00
Fluoranthene	1.07E+05	2.06E-01	5.16E+00
Fluorene	1.38E+04	1.90E+00	4.18E+00
Methyl-2-pentanone[4-]	na[d]	na	na
Methylnaphthalene[2-]	2.976E+03[b]	2.46E+01[b]	3.86E+00
Methylphenol [4-]	na	na	na
Naphthalene	2.00E+03	3.10E+01	3.30E+00
Phenanthrene	1.40E+04	1.15E+00	4.46E+00
Pyrene	1.05E+05	1.35E-01	4.88E+00
Pyridine	3.30E+01[b]	1E+06[b]	6.50E-01

[a] NMED SSL (NMED 2006, 092513) unless otherwise noted.

[b] RAIS database value.

[c] EPA Region 6 value (EPA 2006, 094321).

[d] na = Not available.

Note that the New Mexico Environment Department (NMED) and the U.S. Environmental Protection Agency (EPA) references must be the most current versions of those guidance documents. Also all sources for values must be footnoted. Additional columns may be used (e.g., inclusion of vapor pressure values), but any modifications must be discussed in advance with the Risk Assessment Project Leader.

Sample Table
Results of Pore-Gas Screening Based on Maximum Detected Concentrations

Chemical	Maximum Detected Concentration (µg/m³)	H'	Groundwater Screening Level (µg/L)	Screening Value
Acetone	840	0.0016	5500[a]	9.5E-02
Benzene	48	0.228	5[b]	4.2E-02
Bromodichloromethane	7.2	0.0656	1.8[a]	6.1E-02
Butanol[1-]	17	0.000347	3700[a]	1.3E-02
Butanone[2-]	54	0.0011	7100[a]	6.9E-03
Carbon disulfide	42	1.2	1000[a]	3.5E-05
Carbon tetrachloride	420	1.25	5[b]	6.7E-02
Chlorodibromomethane	0.89	0.035	1.3[a]	2.0E-02
Chloroform	1400	0.15	100[c]	9.3E-02
Chloromethane	2.9	0.98	21[a]	1.4E-04
Cyclohexane	13	7.24	13,000[a]	1.4E-07
Dichlorobenzene[1,4-]	35	0.0996	75[b]	4.7E-03
Dichlorodifluoromethane	9.6	4.1	390[a]	6.0E-06
Dichloroethane[1,1-]	39	0.23	25[c]	6.8E-03
Dichloroethane[1,2-]	150	0.0401	5[b]	7.5E-01
Dichloroethene[1,1-]	170	1.1	5[c]	3.1E-02
Dichloroethene[cis-1,2-]	7.6	0.167	70[b]	6.5E-04
Dichloropropane[1,2-]	11	0.11	5[b]	2.0E-02
Ethylbenzene	9.4	0.323	700[b]	4.2E-05
Hexane	30	5	420[a]	1.4E-05
Methylene chloride	2200	0.09	5[b]	4.9E+00
Styrene	140	0.11	100[b]	1.3E-02
Tetrachloroethene	1500	0.754	5[b]	4.0E-01
Toluene	1900	0.272	750[c]	9.3E-03
Trichloro-1,2,2-trifluoroethane[1,1,2-]	40	21.4	59,000[a]	3.2E-08
Trichloroethane[1,1,1-]	1500	0.705	60[c]	3.5E-02
Trichloroethane[1,1,2-]	61	0.0374	5[b]	3.3E-01
Trichlorofluoromethane	1.5	4.0	1300[a]	2.9E-07
Trichloroethene	2000	0.422	5[b]	9.5E-01
Trimethylbenzene[1,2,4-]	15	0.23	12[a]	5.4E-03
Trimethylbenzene[1,3,5-]	0.56	0.32	12[a]	1.5E-04
Vinyl acetate	6.4	0.021	410[a]	7.4E-04
Vinyl chloride	1.4	1.11	1[c]	1.3E-03
Xylene[1,2-]	17	0.213	620[c]	1.3E-04
Xylene[1,3-]+Xylene[1,4-]	9.5	0.3	620[c]	5.1E-05
Xylenes[total]	15	0.3	620[c]	8.1E-05

[a] EPA Region 6 tap water screening level (EPA 2006, 094321).

[b] EPA MCL.

[c] WQCC groundwater standard.

Sample Table
Results of Pore-Gas Screening Based on Deepest Detected Concentrations

Chemical	Deepest Detected Concentration (µg/m³)	H'	Groundwater Screening Level (µg/L)	Screening Value
Acetone	55	0.0016	5500[a]	6.3E-03
Benzene	2.8	0.228	5[b]	2.5E-03
Bromodichloromethane	5.8	0.0656	1.8[a]	4.9E-02
Butanol[1-]	17	0.000347	3700[a]	1.3E-02
Butanone[2-]	11	0.0011	7100[a]	1.4E-03
Carbon disulfide	42	1.2	1000[a]	3.5E-05
Carbon tetrachloride	1.4	1.25	5[b]	2.2E-04
Chlorodibromomethane	0.89	0.035	1.3[a]	2.0E-02
Chloroform	13	0.15	100[c]	8.7E-04
Chloromethane	1.4	0.98	21[a]	6.8E-05
Cyclohexane	13	7.24	13,000[a]	1.4E-07
Dichlorobenzene[1,4-]	35	0.0996	75[b]	4.7E-03
Dichlorodifluoromethane	2.9	4.1	390[a]	1.8E-06
Dichloroethane[1,1-]	39	0.23	25[c]	6.8E-03
Dichloroethane[1,2-]	150	0.0401	5[b]	7.5E-01
Dichloroethene[1,1-]	170	1.1	5[c]	3.1E-02
Dichloroethene[cis-1,2-]	7.6	0.167	70[b]	6.5E-04
Dichloropropane[1,2-]	11	0.11	5[b]	2.0E-02
Ethylbenzene	9.4	0.323	700[b]	4.2E-05
Hexane	8.9	5	420[a]	4.2E-06
Methylene chloride	2.9	0.09	5[b]	6.4E-03
Styrene	5.1	0.11	100[b]	4.6E-04
Tetrachloroethene	7	0.754	5[b]	1.9E-03
Toluene	11	0.272	750[c]	5.4E-05
Trichloro-1,2,2-trifluoroethane[1,1,2-]	40	21.4	59,000[a]	3.2E-08
Trichloroethane[1,1,1-]	1500	0.705	60[c]	3.5E-02
Trichloroethane[1,1,2-]	61	0.0374	5[b]	3.3E-01
Trichlorofluoromethane	1.5	4.0	1300[a]	2.9E-07
Trichloroethene	4.4	0.422	5[b]	2.1E-03
Trimethylbenzene[1,2,4-]	6.4	0.23	12[a]	2.3E-03
Trimethylbenzene[1,3,5-]	0.56	0.32	12[a]	1.5E-04
Vinyl acetate	2.1	0.021	410[a]	2.4E-04
Vinyl chloride	0.63	1.11	1[c]	5.7E-04
Xylene[1,2-]	1.2	0.213	620[c]	9.1E-06
Xylene[1,3-]+Xylene[1,4-]	9.5	0.3	620[c]	5.1E-05
Xylenes[total]	4	0.3	620[c]	2.2E-05

[a] EPA Region 6 tap water screening level (EPA 2006, 094321).

[b] EPA MCL.

[c] WQCC groundwater standard.

Sample Table
Parameters Used to Calculate Chemical SSLs

Parameters	Residential Values	Industrial Worker Values	Construction Worker Values
Target HQ	1	1	1
Target cancer risk	10^{-5}	10^{-5}	10^{-5}
Averaging time (carcinogen)	70 yr x 365 days	70 yr x 365 days	1 yr x 365 days
Averaging time (noncarcinogen)	ED x 365 days	ED x 365 days	1 yr x 365 days
Skin absorption factor	SVOC = 0.1	SVOC = 0.1	SVOC = 0.1
	Chemical-specific	Chemical-specific	Chemical-specific
Adherence factor–child	0.2 mg/cm^2	n/a[a]	n/a[a]
Body weight–child	15 kg (0–6 years of age)	n/a	n/a
Cancer slope factor–oral (chemical-specific)	(mg/kg-day)$^{-1}$	(mg/kg-day)$^{-1}$	(mg/kg-day)$^{-1}$
Cancer slope factor–inhalation (chemical-specific)	(mg/kg-day)$^{-1}$	(mg/kg-day)$^{-1}$	(mg/kg-day)$^{-1}$
Exposure frequency	350 day/yr	225 day/yr	250 day/yr
Exposure duration–child	6 yr (0–6 yr of age)	n/a	n/a
Age-adjusted ingestion factor	114 mg–yr/kg–day	n/a	n/a
Age-adjusted inhalation factor	11 m^3–yr/kg–day	n/a	n/a
Inhalation rate–child	10 m^3/day	n/a	n/a
Soil ingestion rate–child	200 mg/day	n/a	n/a
Particulate emission factor	6.61 x 10^9 m^3/kg	6.61 x 10^9 m^3/kg	2.12 x 10^6 m^3/kg
Reference dose–oral (chemical-specific)	(mg/kg–day)	(mg/kg-day)	(mg/kg-day)
Reference dose–inhalation (chemical-specific)	(mg/kg–day)	(mg/kg-day)	(mg/kg-day)
Exposed surface area–child	2800 cm^2/day (head, hands, forearms, lower legs, feet)	n/a	n/a
Age-adjusted skin contact factor for carcinogens	361 mg–yr/kg–day	n/a	n/a
Volatilization factor for soil (chemical-specific)	(m^3/kg)	(m^3/kg)	(m^3/kg)
Body weight–adult	70 kg	70 kg	70 kg
Exposure duration[b]	30 yr	25	1
Adherence factor–adult	0.07 mg/cm^2	0.2 mg/cm^2	0.3 mg/cm^2
Soil ingestion rate–adult	100 mg/day	100 mg/day	330 mg/day
Exposed surface area–adult	5700 cm^2/day (head, hands, forearms, lower legs)	3300 cm^2/day (head, hands, forearms)	3300 cm^2/day (head, hands, forearms)
Inhalation rate–adult	20 m^3/day	20 m^3/day	20 m^3/day

Note: Parameter values from NMED 2006, 092513.

[a] n/a = Not applicable.

[b] Exposure duration for lifetime resident is 30 yr. For carcinogens, the exposures are combined for child (6 yr) and adult (24 yr).

Sample Table
Parameters Used in the SAL Calculations for Radionuclides, Industrial

Parameters	Industrial, Adult
Inhalation rate (m^3/yr)	19,481[a]
Mass loading (g/m^3)	1.5×10^{-7} [b]
Outdoor time fraction	0.2053[c]
Indoor time fraction	0
Soil ingestion (g/yr)	97.4[d]

[a] Calculated as [20 m^3/day × 225 day/yr] / [indoor + outdoor time fractions], where 20 m^3/day is the daily inhalation rate of an adult and 225 days/yr is the exposure frequency (NMED 2006, 092513).

[b] Calculated as [1/ $6.6 \times 10^{+9}$ m^3/kg) × 1000 g/kg, where $6.6 \times 10^{+9}$ m^3/kg is the particulate emission factor (NMED 2006, 092513).

[c] Calculated as [8 hr/day × 225 day/yr] / 8766 hr/yr, where 8 hr/day is an estimate of the average length of the work day.

[d] Calculated as [0.1 g/day × 225 day/yr] / [indoor + outdoor time fractions], where 0.1 g/day is the adult soil ingestion rate (NMED 2006, 092513).

Sample Table
Parameters Used in the SAL Calculations for Radionuclides, Residential

Parameters	Residential, Child	Residential, Adult
Inhalation rate (m^3/yr)	3652.5[a]	7305[b]
Mass loading (g/m^3)	1.5×10^{-7}[c]	1.5×10^{-7}[c]
Outdoor time fraction	0.2236[d]	0.0599[e]
Indoor time fraction	0.7347[f]	0.8984[g]
Soil ingestion (g/yr)	73[h]	36.5[i]

[a] Calculated as [10 m^3/day × 350 day/yr] / [indoor + outdoor time fractions], where 10 m^3/day is the daily inhalation rate of a child (NMED 2006, 092513).

[b] Calculated as [20 m^3/day × 350 day/yr] / [indoor + outdoor time fractions], where 20 m^3/day is the daily inhalation rate of an adult (NMED 2006, 092513).

[c] Calculated as [1/ $6.6 \times 10^{+9}$ m^3/kg) × 1000 g/kg, where $6.6 \times 10^{+9}$ m^3/kg is the particulate emission factor (NMED 2006, 092513).

[d] Calculated as [5.6 hr/day × 350 day/yr] / 8766 hr/yr, where 5.6 hr/day is an estimate of time spent outdoors for a 3–11 yr old child (EPA 1997, 066598, section 15.4-1).

[e] Calculated as [1.5 hr/day × 350 day/yr] / 8766 hr/yr, where 1.5 hr/day is an estimate of time spent outdoors for an adult 12 yr and older (EPA 1997, 066598, section 15.4-1).

[f] Calculated as [(24–5.6 hr/day × 350 day/yr] / 8766 hr/yr.

[g] Calculated as [(24–1.5 hr/day × 350 day/yr] / 8766 hr/yr.

[h] Calculated as [0.2 g/day × 350 day/yr] / [indoor + outdoor time fractions], where 0.2 g/day is the child soil ingestion rate (NMED 2006, 092513).

[i] Calculated as [0.1 g/day × 350 day/yr] / [indoor + outdoor time fractions], where 0.1 g/day is the adult soil ingestion rate (NMED 2006, 092513).

Sample Table
Parameters Used in the SAL Calculations for Radionuclides, Construction Worker

Parameters	Construction Worker, Adult
Inhalation rate (m^3/yr)	19,478[a]
Mass loading (g/m^3)	0.0004[b]
Outdoor time fraction	0.2567[c]
Indoor time fraction	0
Soil ingestion (g/yr)	321[d]

[a] The inhalation rate compensates for the time-based occupancy factor applied by RESRAD in calculating exposure from the inhalation pathway. Per the NMED calculation, the (daily) inhalation rate is not modified by any assumed daily time fraction on-site. Calculated as [20 m^3/day × 250 day/yr] / [indoor + outdoor time fractions], where 20 m^3/day is the daily inhalation rate of an adult and 250 days/yr is the exposure frequency (NMED 2006, 092513).

[b] Calculated as (1 / 2.1 × 10^{+6} m^3/kg) × 1000 g/kg, where 2.1 × 10^{+6} m^3/kg is the particulate emission factor (NMED 2006, 092513).

[c] Calculated as (9 hr/day × 250 day/yr) / 8766 hr/yr, where 9 hr/day is an estimate of the average length of the work day, including a 1-hr break.

[d] The soil-ingestion rate compensates for the time-based occupancy factor applied by RESRAD in calculating exposure from the soil ingestion pathway. Calculated as [0.33 g/day × 250 day/yr] / [indoor + outdoor time fractions], where 0.33 g/day is the soil ingestion rate for a construction worker (NMED 2006, 092513).

Sample Table
Toxicity Equivalency for Dioxin

COPCs	Number of Analyses	95% UCL (mg/kg)	TEFs *	Adjusted EPC (mg/kg)
Dioxins				
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	10	4.95E-07	0.01	4.95E-09
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	10	1.18E-07	0.1	1.18E-08
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	10	2.58E-06	0.0001	2.58E-10
Furans				
Pentachlorodibenzofuran[1,2,3,7,8-]	10	8.95E-08	0.05	4.48E-09
Pentachlorodibenzofuran[2,3,4,7,8-]	10	8.73E-08	0.5	4.37E-08
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	10	4.49E-06	0.01	4.49E-08
Hexachlorodibenzofuran[1,2,3,4,7,8-]	10	2.10E-06	0.1	2.10E-07
Hexachlorodibenzofuran[1,2,3,6,7,8-]	10	5.75E-07	0.1	5.75E-08
Hexachlorodibenzofuran[2,3,4,6,7,8-]	10	1.95E-07	0.1	1.95E-08
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	10	1.81E-06	0.0001	1.81E-10
			TEQ for TCDD	**4.0E-07**

*TEFs from http://www.epa.gov/ncea/pdfs/dioxin/part2/drich9.pdf

Sample Table
Risk Screening Comparison for the Industrial Scenario

Analyte	EPC[a] (mg/kg)	Industrial SSL[b] (mg/kg)	Cancer Risk
Arsenic	2.96	17.7	1.67E-06
Aroclor-1242	0.0078[c]	8.26	9.40E-09
Aroclor-1254	0.0115[c]	8.26	1.40E-08
Aroclor-1260	0.0058[c]	8.26	7.00E-09
Benzo(a)anthracene	0.221	23.4	9.40E-08
Benzo(a)pyrene	0.227	2.34	9.70E-07
Benzo(b)fluoranthene	0.218	23.4	9.30E-08
Benzo(k)fluoranthene	0.218	234	9.30E-09
Chromium	17.8	5000[d]	3.56E-08
Chrysene	0.221	2340[e]	9.50E-10
Dibenz(a,h)anthracene	0.17[c]	2.34	7.3E-07
Dichlorobenzidine[3,3'-]	0.224	42.6	5.30E-08
Indeno(1,2,3-cd)pyrene	0.209	23.4	8.90E-08
		Total Excess Cancer Risk	**4.0E-06**

[a] Concentration is the 95% UCL, unless otherwise indicated.

[b] SSLs from NMED (2006, 092513), unless otherwise indicated.

[c] Maximum detected concentration used.

[d] SSL from EPA Region 6 (EPA 2006, 094321).

[e] Value from the forward risk evaluation table (refer to table number, for example, Table H-4.1-6).

Sample Table
Comparison to Noncarcinogenic SSLs for the Industrial Scenario

Analyte	EPC[a] (mg/kg)	Industrial SSL[b] (mg/kg)	HQ
Cadmium	0.635	564	0.0011
Cobalt	4.00	20500	0.00020
Copper	10.4	45400	0.00023
Lead	16.7	800	0.021
Mercury	0.249	340[c]	0.000732
Perchlorate	0.00058[d]	790[c]	0.00000059
Pyridine	0.0781[d]	680[c]	0.00011
Selenium	0.493	5680	0.000087
Silver	0.59[d]	5680	0.0001
Thallium	0.369	74.9	0.0049
Uranium	5.34	200[e]	0.026
Zinc	82.1	100000[f]	0.00082
Acenaphthene	0.201	68100[g]	0.0000030
Anthracene	0.227	100000	0.0000023
Aroclor-1254	0.0115[d]	12[c]	0.000958
Benzo(g,h,i)perylene[h]	0.209	34100[g]	0.0000061
Benzoic acid	0.97	100000[f]	0.0000097
Butyl benzyl phthalate	0.22	100000[f]	0.0000022
Dibenzofuran	0.2[d]	4540[g]	0.000044
Diethylphthalate	0.702	100000[f]	0.000007
Fluoranthene	0.410	24400	0.000017
Fluorene	0.200	45400[g]	0.0000044
Methylnaphthalene[2-][i]	0.095[d]	92.5	0.0010
Methylphenol[4-]	0.11[d]	3400[c]	0.000032
Naphthalene	0.194	92.5	0.0021
Phenanthrene	0.407	20500	0.000020
Pyrene	0.319	34100[g]	0.0000094
		HI	**0.06**

[a] Concentration is the 95% UCL, unless otherwise indicated.

[b] SSLs from NMED (2006, 092513), unless otherwise indicated.

[c] SSL from EPA Region 6 (EPA 2006, 094321).

[d] Maximum detected concentration used.

[e] SSL from EPA Region 9 (http://www.epa.gov/region9/waste/sfund/prg/files/04prgtable.pdf.)

[f] Maximum allowable concentration used as SSL per NMED guidance (NMED 2006, 092513).

[g] Value from the forward risk evaluation table (refer to table number, for example, Table H-4.1-6).

[h] Pyrene used as a surrogate based on structural similarity.

[i] Naphthalene used as a surrogate based on structural similarity.

Sample Table
Radionuclide SAL Comparisons for the Industrial Scenario

Analyte	EPC[a] (pCi/g)	Industrial SAL[b] (pCi/g)	Dose (mrem/yr)
Americium-241	0.094	180	0.0078
Cesium-137	0.808	23	0.525
Plutonium-238	0.173	240	0.0108
Plutonium-239	0.645	210	0.0465
Strontium-90	0.240	1900	0.00195
Tritium	1.24	440000	0.000045
Uranium-234	4.96	1500	0.0495
Uranium-235	0.251	87	0.0435
		Total Dose	**0.7**

[a] Concentration is the 95% UCL.

[b] SALs from LANL (2005, 088493).

Note that if more than one scenario is evaluated, the screening comparisons can be presented in one table per risk/hazard/dose, as shown in the sample tables below. Also, the screening comparisons for each solid waste management unit, area of concern, or consolidated unit evaluated must be presented separately.

Sample Table
Carcinogenic Screening Evaluation for ...

COPC	95% UCL 0 to 1 ft bgs (mg/kg)	Industrial SSL[a] (mg/kg)	Industrial Cancer Risk	95% UCL 0 to 10 ft bgs (mg/kg)	Residential SSL[a] (mg/kg)	Residential Cancer Risk	95% UCL 0 to 10 ft bgs (mg/kg)	Con Wor (
Inorganic Chemicals								
Arsenic[b]	2.31	1.77E+01	1.3E-06	2.16	3.9E+00	5.55E-06	na[b]	na[b]
Chromium	7.55	5E+03[c]	1.51E-08	12.2	2.1E+03[b]	5.79E-08	10	2.61E
Semivolatile Organic Compounds								
Benzo(a)anthracene	0.217	2.34E+01	9.27E-08	0.199	6.21E+00	3.2E-07	n/a[e]	2.12E
Benzo(a)pyrene	0.199	2.34E+00	8.51E-07	0.205	6.21E-01	3.29E-06	0.118	2.12E
Benzo(b)fluoranthene	0.231	2.34E+01	9.86E-08	0.204	6.21E+00	3.29E-07	0.141	2.12E
Benzo(k)fluoranthene	0.229	2.3E+02	9.79E-09	0.197	6.2+01	3.17E-08	n/a[e]	2.12+
Bis(2-ethylhexyl)phthalate	0.131	1.37E+03	9.57E-10	0.21	3.47E+02	6.07E-09	na[b]	na[b]
Chrysene	0.216	2.31E+03	9.33E-10	0.199	6.15E+02	3.24E-09	0.109	2.12E
Dioxin (2,3,7,8-TCDD)[f]	n/a[e]	1.80E-04	n/a[e]	3.97E-07	3.9E-05[g]	1.02E-07	n/a[e]	No S
Indeno(1,2,3-cd)pyrene	0.232	2.34E+01	9.91E-08	0.209	6.21E+00	3.22E-07	0.138	2.12E
Volatile Organic Compounds								
Methylene Chloride	n/a[e]	4.90E+02	n/a[e]	0.01	1.82E+02	5.71E-10	n/a[e]	2.63E
Tetrachloroethene	n/a[e]	3.16E+01	n/a[e]	0.006	1.25E+01	5.13E-09	n/a[e]	1.34E
Trichloroethene	n/a[e]	1.56E+00	n/a[e]	0.004	6.38E-01	6.99E-08	n/a[e]	3.36E
Total Excess Cancer Risk			**2.0E-06**	**Total Excess Cancer Risk**		**1.0E-05**	**Total Excess Ca**	

[a] SSLs from NMED (2006, 092513), unless otherwise noted.

[b] na = Not available. SSL is based on a noncarcinogenic effect, no carcinogenic SSL is available in either NMED (2006, 092513) or EPA (2006, 094321)

[c] SSL from EPA Region 6 adjusted to 10^{-5} target risk (EPA 2006, 094321).

[d] SSL from NMED for hexavalent chromium (NMED 2006, 092513).

[e] n/a = Not applicable; analyte was not a COPC for this exposure scenario.

[f] TCDD used based on TEFs (see Table J-4.1-6).

[g] SSL from EPA Region 6 for 2,3,7,8-TCDD (dioxin) (EPA 2006, 094321).

Sample Table
Noncarcinogenic Screening Evaluation for ...

COPC	95% UCL 0 to 1 ft bgs (mg/kg)	Industrial SSL[a] (mg/kg)	Industrial HQ	95% UCL 0 to 10 ft bgs (mg/kg)	Residential SSL[a] (mg/kg)	Residential HQ	95% UCL 0 to 10 ft bgs (mg/kg)	Con W (
Inorganic Chemicals								
Aluminum	n/a[b]	1.00E-05	n/a	8211	7.78E+04	1.06E-01	14201	1.44
Antimony	n/a	4.54E+02	n/a	2.48	3.13E+01	7.91E-02	n/a	n/a
Arsenic	2.31	2.8E+02	8.11E-03	2.16	2.2E+01[c]	3.94E-02	3.08	8.52
Barium	113	1.00E+05[d]	113E-03	124	1.56E+04	7.98E-03	111	6.02
Beryllium	22	2.25E+03	9.78E-03	8.52	1.56E+02	5.46E-02	0.831	5.62
Cadmium	0.699	5.64E+02	1.24E-03	1.65	3.90E+01	4.24E-02	0.78	1.54
Chromium	7.55	3.40E+03[e]	2.22E-03	12.2	2.34E+02[e]	5.21E-02	10	100,
Cobalt	4.88	2.05E+04	2.38E-04	4.6	1.52E+03	3.03E-03	4.29	6.10
Copper	5.52	4.54E+04	1.22E-04	10.2	3.13E+03	3.26E-03	6.46	1.24
Iron	9847	1.00E+05[d]	9.85E-02	10977	9.29E+04	1.18E-01	8706	2.35
Lead	12.9	8.00E+02	1.61E-02	13.8	4.00E+02	3.45E-02	15.3	8.00
Lithium	8.04	2.30E+04[c]	3.54E-04	8.03	1.6E+03[c]	5.14E-03	n/a	No S
Manganese	n/a	4.84E+04	n/a	284	3.59E+03	7.93E-02	321	1.50
Mercury	0.02	3.40E+02[f]	6.02E-05	1.52	2.3E+01[f]	6.48E-02	0.077	9.37
Nickel	6.52	2.27E+04	2.87E-04	10.1	1.56E+03	6.49E-03	6.61	6.19
Nitrate	n/a	1.00E+05[d]	n/a	32.1[h]	1.00E+05[d]	3.21E-04	32.1[h]	1.00
Perchlorate	0.002	7.90E+02[c]	2.52E-06	0.0016	5.5E+01[c]	2.84E-05	0.0018	7.9E
Selenium	0.368	5.68E+03	6.48E-05	0.69	3.91E+02	1.77E-03	n/a	n/a
Silver	n/a	5.68E+03	n/a	1.15	3.91E+02	2.94E-03	0.111	1.55
Strontium	22.6	1.00E+05[d]	2.26E-04	22.7	4.69E+04	4.84E-04	n/a	n/a
Thallium	0.115	7.49E+01	1.54E-03	0.28	5.16E+00	5.41E-02	0.238	2.04
Vanadium	n/a	1.14E+03	n/a	14.5	7.82E+01	1.86E-01	18.1	3.10
Zinc	46.2	1.00E+05[d]	4.72E-04[d]	44	2.35E+04	1.83E-03	49.8	9.29

Sample Table (continued)

COPC	95% UCL 0 to 1 ft bgs (mg/kg)	Industrial SSL[a] (mg/kg)	Industrial HQ	95% UCL 0 to 10 ft bgs (mg/kg)	Residential SSL[a] (mg/kg)	Residential HQ	95% UCL 0 to 10 ft bgs (mg/kg)	Co
Semivolatile Organic Compounds								
Acenaphthene	n/a	3.35E+04	n/a	n/a	3.73E+03	n/a	n/a	1.4
Acenaphthylene[i]	n/a	3.09E+04	n/a	n/a	2.29E+03	n/a	0.137	9.0
Anthracene	n/a	1.00E+05[d]	n/a	0.201	2.20E+04	9.13E-06	n/a	8.6
Benzo(g,h,i)perylene[i]	n/a	3.09E+04	n/a	0.199	2.29E+03	8.73E+05	0.137	9.0
Benzoic acid	1.03	1.00E+05[c,d]	1.03E-05	1.04	1.00E+05[c,d]	1.03E-05[d]	2.74	1.0
Bis(2-ethylhexyl)phthalate	0.131	14000[c]	9.36E-06	0.21	1200[c]	1.75E-04	0.664	4.6
Butanone(2-)	n/a	4.87E+04	n/a	0.011	3.18E+04	3.56E-07	n/a	4.7
Dibromo-3-chloropropane(1,2-)	n/a	9.68E+00	n/a	0.0062	1.84E+00	3.36E-03	n/a	6.4
Di-n-butylphthalate	0.244	6.84E+04	3.57E-06	0.316	6.11E+03	5.16E-05	n/a	2.3
Fluoranthene	0.226	2.44E+04	9.28E-06	0.253	2.29E+03	1.10E-04	0.12	8.7
Phenanthrene	0.217	2.05E+04	1.06E-05	0.209	1.83E+03	1.14E-04	0.103	6.9
Pyrene	0.22	3.09E+04	7.13E-06	0.228	2.29E+03	9.94E-05	0.125	9.0
Volatile Organic Compounds								
Acetone	n/a	1.00E+05[d]	n/a	0.013	2.81E+04	4.72E-07	n/a	9.8
Hexanone[2-][j]	n/a	3.18E+04	n/a	0.013	3.18E+04	4.04E-07	n/a	4.8
Isopropyltoluene[4-][k]	n/a	2.71E+02	n/a	0.0035	2.71E+02	1.28E-05	n/a	3.8
Toluene	n/a	2.52E+02	n/a	0.024	C_{sat} SSL[l]	6E-05	n/a	2.5

Sample Table (continued)

COPC	95% UCL 0 to 1 ft bgs (mg/kg)	Industrial SSL[a] (mg/kg)	Industrial HQ	95% UCL 0 to 10 ft bgs (mg/kg)	Residential SSL[a] (mg/kg)	Residential HQ	95% UCL 0 to 10 ft bgs (mg/kg)	Con W (
Trichlorofluoromethane	n/a	9.83E+02	n/a	0.0029	5.88E+02	4.95E-06	n/a	9.83
Xylene[1,3-]+xylene[1,4-]	n/a	8.02E+01	n/a	0.0013	C_{sat} SSL[l]	1.16E-05	n/a	8.02
		HI	**0.14**		**HI**	**1.2**		

[a] SSLs from NMED (2006, 092513), unless otherwise noted.

[b] n/a = Not applicable; analyte was not a COPC for this scenario.

[c] SSL from EPA Region 6 (EPA 2006, 094321).

[d] Maximum allowable concentration per NMED (2006, 092513) and EPA (2006, 094321).

[e] SSLs for industrial and residential are for hexavalent chromium and the SSL for construction worker is for trivalent chromium from NMED (2006, 09251

[f] SSL from EPA Region 6 (EPA 2006, 094321).

[g] No SSL for inorganic mercury is available for construction worker; NMED SSL for elemental mercury used (NMED 2006, 092513).

[h] Maximum detected concentration used

[i] Pyrene is used as surrogate based on structural similarity.

[j] Butanone[2-] used as a surrogate based on structural similarity.

[k] Isopropylbenzene used as a surrogate based on structural similarity.

[l] NMED SSL based on soil saturation concentration. Forward risk calculations were performed and are shown in Table X-X.X-X.

Sample Table
Forward Risk Evaluation for COPCs at ...

Analyte	Residential Concentration (mg/kg)	C_{sat} Concentration* (mg/kg)	RfD—Oral* (mg/kg-day)	RfD—Inhalation* (mg/kg-day)	Volatili Fact (m^3/
Toluene	0.024	252	8.00E-02	1.40E-00	59
Xylene[1,3-]+Xylene[1,4-]	0.0013	82	2.00E-01	2.88E-02	54

*Values from NMED (2006, 092513).

Note that this table is necessary for only those organic chemicals that have C_{sat} SSLs. Alternatively, if EPA Region 6 has r levels in its detailed spreadsheet, which can be accessed online or downloaded from the web page, these values may be forward risk calculation. However, this deviation must be stated in the text and footnoted in the tables.

Appendix C

Surrogate Chemicals in the Risk Assessment

Some chemicals do not have published toxicity values (i.e., cancer slope factor or reference dose) in the U.S. Environmental Protection Agency's (EPA's) Integrated Risk Information System (IRIS) database, Health Effects Assessment Summary Tables (HEAST), or National Center for Environmental Assessment (NCEA) publications. As part of the screening assessment, the risk assessor may either qualitatively discuss the presence of the chemical and the implications of the absence of the chemical from the risk estimate or evaluate the chemical quantitatively. If it is determined a baseline risk assessment is appropriate, the chemical is retained as a chemical of potential concern (COPC) and evaluated as part of the potential overall risk.

The quantitative evaluation may involve the calculation of a soil screening level (SSL) using toxicity data from sources other than those described above along with the equations and parameters presented in this methodology. Alternatively, the SSL of an appropriately similar chemical based on toxicity and/or chemical structure (i.e., a surrogate, may be used in the screening assessment). Subsequently, a discussion of the uncertainty related to the use of a surrogate is necessary for a risk management decision. The use of a surrogate may cause an under- or overestimation of risk.

The chemicals presented in Table C-1 have been detected but do not have SSLs because adequate toxicity information is not available. These chemicals can potentially be evaluated using the SSLs for similar chemicals listed in the table. This list of surrogates is in agreement with the New Mexico Environment Department's approval memorandum, dated November 24, 2003 (NMED 2003, 081172), but is not intended to be all inclusive.

Table C-1
Chemicals with Inadequate Toxicity Information and Corresponding Surrogate Chemicals

Chemical	Surrogate Chemical	Rationale
Acenaphthylene	Pyrene	Structure similarity
2-Amino-4,6-dinitrotoluene	2,6-Dinitrotoluene	Structure similarity
4-Amino-2,6-dinitrotoluene	2,6-Dinitrotoluene	Structure similarity
Benzo(g,h,i)perylene	Pyrene	Structure similarity
Endosulfan I	Endosulfan	Endosulfan I is an isomer of Endosulfan
Endosulfan II	Endosulfan	Endosulfan II is an isomer of Endosulfan
Endosulfan Sulfate	Endrin	Structure similarity
Endrin Aldehyde	Endrin	Endrin Aldehyde is an impurity and breakdown product of Endrin
Endrin ketone	Endrin	Endrin Ketone is the primary metabolite of Endrin
2-Hexanone	2-Butanone	Structure similarity
Isopropyltoluene	Isopropylbenzene	Structure similarity
2-Methylnaphthalene	Naphthalene	Structure similarity
3-Nitroaniline	2-Nitroaniline	Structure similarity
4-Nitroaniline	2-Nitroaniline	Structure similarity
2-Nitrophenol	2-Chlorophenol	Structure similarity
Phenanthrene	Pyrene	Structure similarity

Acenaphthylene The surrogate chemical is pyrene. The difference between the two chemicals is an additional benzene ring for pyrene (Figure C-1).

2-Amino-4,6-dinitrotoluene The surrogate chemical is 2,6-dinitrotoluene. The difference between the two chemicals is the addition of an amino group (NH_2), the position of that amino group and the position of the nitro group (NO_2) (Figure C-2). Because there are fewer sites for reactions to occur on the surrogate 2,6-dinitrotoluene, the surrogate will be less reactive than 2-amino-4,6-dinitrotoluene.

4-Amino-2,6-dinitrotoluene The surrogate chemical is 2,6-dinitrotoluene. The difference between the two chemicals is the addition of an amino group (NH_2) (Figure C-2). Because there are fewer sites for reactions to occur on the surrogate 2,6-dinitrotoluene, the surrogate will be less reactive than 4-amino-2,6-dinitrotoluene.

Benzo(g,h,i)perylene The surrogate chemical is pyrene. The difference between the two chemicals is the addition of two benzene rings (Figure C-3). The additional benzene rings add stability to the structure, making the surrogate pyrene more reactive than benzo(g,h,i)perylene.

Endosulfan I The surrogate chemical is endosulfan. Endosulfan I is an isomer of endosulfan. These chemicals have the same chemical weight and the same molecules. The melting point of endosulfan and endosulfan I is 106°C and 108°C, respectively. A comparison of structure is presented in Figure B-4.

Endosulfan II The surrogate chemical is endosulfan. Endosulfan II is an isomer of endosulfan. These chemicals have the same chemical weight and the same molecules. The melting point of endosulfan and Endosulfan II is 106°C and 207°C, respectively. A comparison of structure is presented in Figure C-4.

Endosulfan Sulfate The surrogate chemical is endrin based on structural similarity. A comparison of structures is presented in Figure C-5.

Endrin Aldehyde The surrogate chemical is endrin. Endrin aldehyde is an impurity and breakdown product of endrin. Photochemical isomerization of endrin was observed after exposure of thin layers of solid endrin on glass to sunlight (ATSDR 1997, 056531). Minor amounts of endrin aldehyde were formed in this reaction. Endrin is also sensitive to transformation by heat, yielding primarily the pentacyclic ketone and endrin aldehyde at temperatures greater than 230°C (ATSDR 1997, 056531). A comparison of structures is presented in Figure C-6.

Endrin Ketone The surrogate chemical is endrin. Endrin ketone is a breakdown product of endrin. Photochemical isomerization of endrin, primarily to the pentacyclic ketone commonly called endrin ketone, was observed after exposure of thin layers of solid endrin on glass to sunlight (ATSDR 1997, 056531). Results of seasonal studies indicated this isomerization proceeds with a half-life of 5 to 9 days in intense summer sunlight, with complete conversion to endrin ketone in 15 to 19 days. A comparison of structures is presented in Figure C-6.

2-Hexanone The surrogate chemical is 2-butanone. The difference between the two chemicals is that 2-hexanone has a longer chain with two carbon and four hydrogen atoms. Under the same conditions, these chemicals react similarly. 2-Hexanone will be less stable because of to the elongated shape that causes a polarity difference between the oxygen and the carbon in the number six position (Figure C-7).

4-Isopropyltoluene The surrogate chemical is isopropylbenzene (cumene) based on structural similarity. The difference between the two chemicals is a carbon molecule in the number two position for 2-isopropyltoluene (Figure C-8). Isopropyltoluene is more reactive because the additional carbon affords an additional reaction site.

2-Methylnaphthalene The surrogate is naphthalene based on structural similarity. The difference between the two chemicals is a carbon molecule in the number three position for 2-methylnaphthalene (Figure C-9). 2-methylnaphthalene is more reactive because the additional carbon affords an additional reaction site.

3-Nitroaniline The surrogate chemical is 2-nitroaniline based on structural similarity. The difference between the two chemicals is the position of the nitro group (NO_2) (Figure C-10). Under the same conditions, these chemicals react similarly.

4-Nitroaniline The surrogate chemical is 2-nitroaniline based on structural similarity. The difference between the two chemicals is the position of the nitro group (NO_2) (Figure C-10). Under the same conditions, these chemicals react similarly.

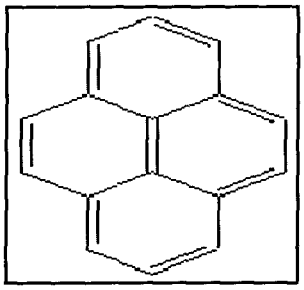
2-Nitrophenol The surrogate chemical is 2-chlorophenol based on structural similarity. The difference between the two chemicals is the chlorine in the position of the nitro group (NO_2) (Figure C-11).

Phenanthrene The surrogate chemical is pyrene based on structural similarity. The difference between the two chemicals is an additional benzene ring for pyrene (Figure C-12).

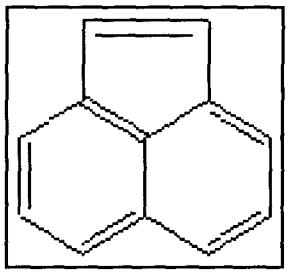
REFERENCES

ATSDR (Agency of Toxic Substances and Disease Registry), 1997. "Toxicological Profiles on CD-ROM; Toxicological Profiles of Endosulfan, Endrin, and Endrin Aldehyde." (ATSDR 1997, 056531)

NMED (New Mexico Environment Department), November 2003. "LANL's Risk Reduction and Environmental Stewardship (RRES) Remediation Services Project Use of Surrogate Chemicals in Risk Assessments," New Mexico Environment Department letter from J. Kieling (NMED) to D. Gregory (DOE) and G.P. Nanos (LANL), Santa Fe, New Mexico. (NMED 2003, 081172)

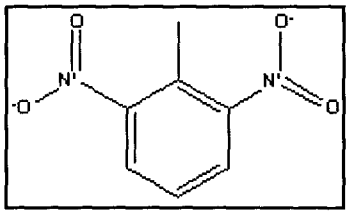


Pyrene
(Surrogate)

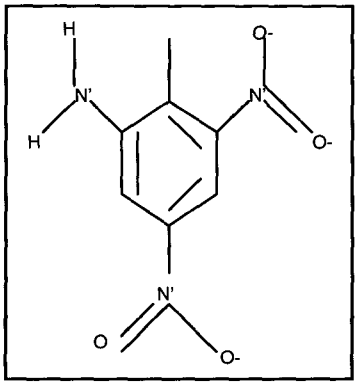


Acenaphthylene

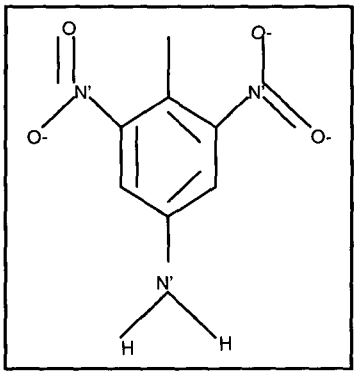
Figure C-1 Structure comparison between pyrene and acenaphthylene



2,6-DNT
(Surrogate)

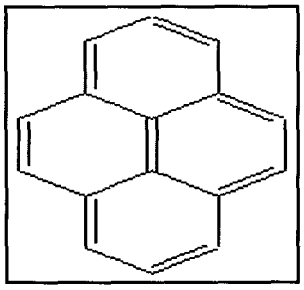


2-Amino-4,6-DNT

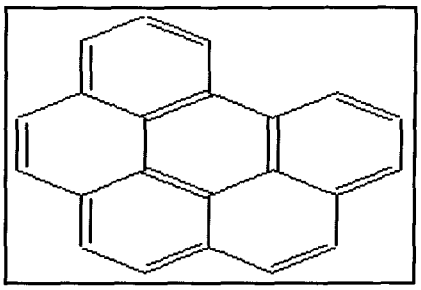


4-Amino-2,6-DNT

Figure C-2 Structure comparison among 2,6-DNT, 2-amino-4,6-DNT, and 4-amino-2,6-DNT

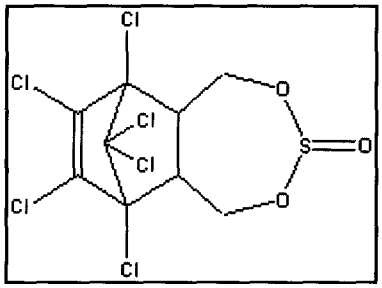


Pyrene
(Surrogate)

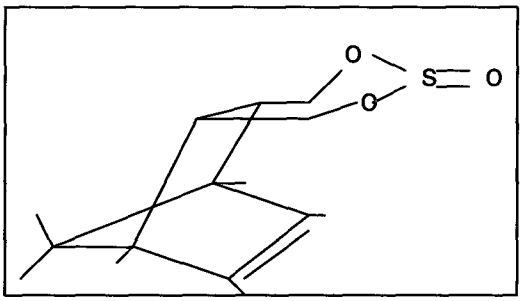


Benzo(g,h,i)perylene

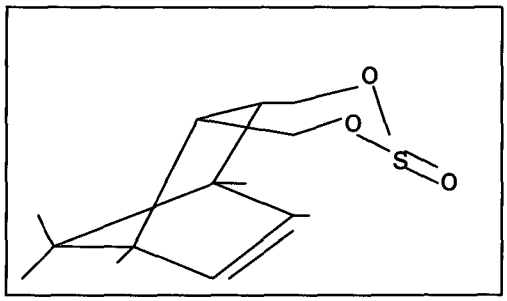
Figure C-3 Structure comparison between pyrene and benzo(g,h,i)perylene



Endosulfan
(Surrogate)

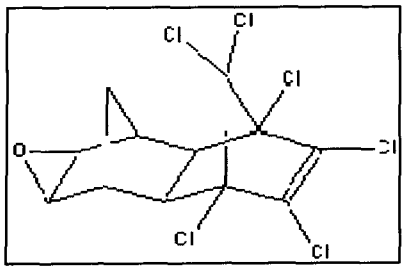


Endosulfan I

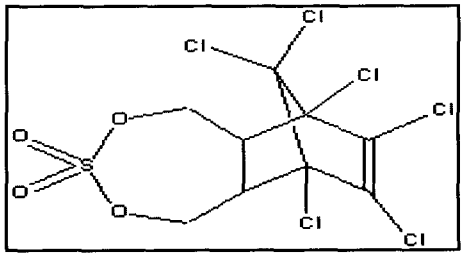


Endosulfan II

Figure C-4 Structure comparison among endosulfan and isomers endosulfan I and endosulfan II

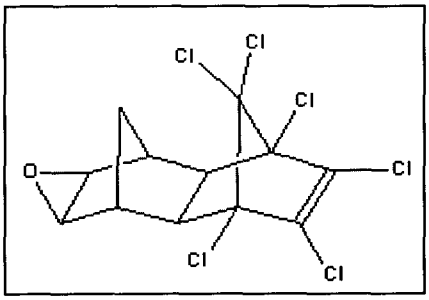


Endrin
(Surrogate)

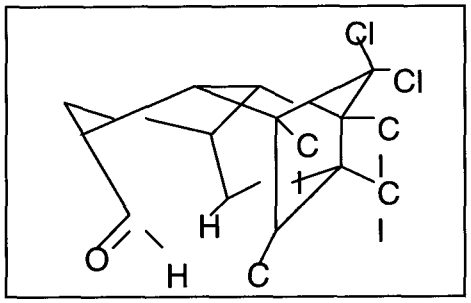


Endosulfan
Sulfate

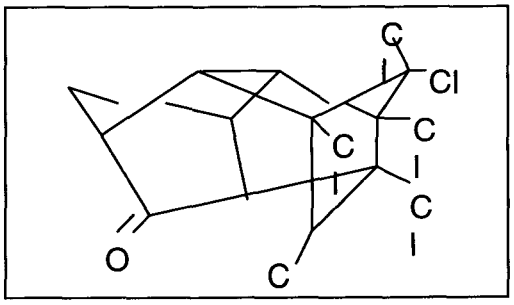
Figure C-5 Structure comparison between endrin and endosulfan sulfate



Endrin
(Surrogate)



Endrin
Aldehyde



Endrin
Ketone

Figure C-6 Structure comparison among endrin, endrin aldehyde, and endrin ketone

2-Butanone
(Surrogate)

2-Hexanone

Figure C-7 Structure comparison between 2-butanone and 2-hexanone

Isopropylbenzene
(Surrogate)

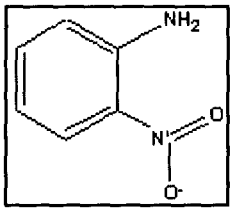
4-Isopropyltoluene

Figure C-8 Structure comparison between isopropylbenzene and 4-isopropyltoluene

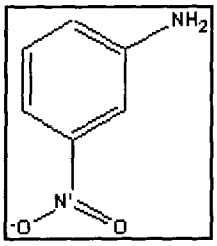
Naphthalene
(Surrogate)

2-Methylnaphthalene

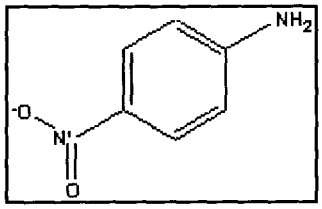
Figure C-9 Structure comparison between naphthalene and 2-methylnaphthalene



2-Nitroaniline
(Surrogate)

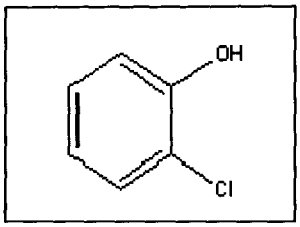


3-Nitroaniline

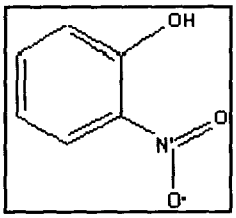


4-Nitroaniline

Figure C-10 Structure comparison among 2-nitroaniline, 3-nitroaniline, and 4-nitroaniline

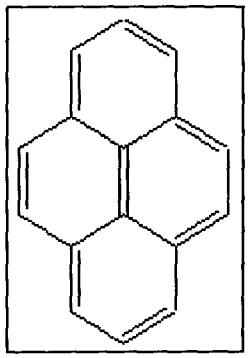


2-Chlorophenol

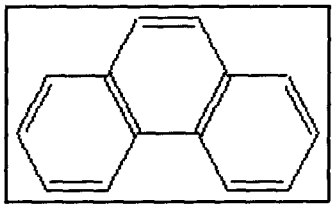


2-Nitrophenol

Figure C-11 Structure comparison between 2-chlorophenol and 2-nitrophenol



Pyrene
(Surrogate)



Phenanthrene

Figure C-12 Structure comparison between pyrene and phenanthrene

Appendix D

Soil Screening Levels for the Recreational Scenario

Analyte	Recreational SSL[a] (mg/kg)	Noncarcinogenic SSL (mg/kg)	Carcinogenic SSL (mg/kg)
Acenaphthene	4.75E+04	4.75E+04	No data[b]
Acenaphthylene[c]	2.38E+04	2.38E+04	No data
Acetaldehyde	2.82E+03	2.82E+03	4.89E+03
Acetone	1.00E+05 (max)[d]	4.53E+05	No data[b]
Acrylonitrile	6.09E+01	3.33E+02	6.09E+01
Acetophenone	1.48E+03(sat)	7.92E+04	No data
Acrolein	5.45E+00	5.45E+00	No data
Aldrin	1.49E+00	1.20E+01	1.49E+00
Aluminum	1.00E+05(max)	7.90E+05	No data
Anthracene	1.00E+05(max)	2.38E+05	No data
Antimony	3.17E+02	3.17E+02	No data
Arsenic	2.77E+01	1.83E+02	2.77E+01
Barium	1.00E+05(max)	1.58E+05	No data
Benzene	1.98E+02	1.08E+03	1.98E+02
Benzidine	1.11E-01	1.20E+03	1.11E-01
Benz(a)anthracene	3.01E+01	No data	3.01E+01
Benzo(a)pyrene	3.01E+00	No data	3.01E+00
Benzo(b)fluoranthene	3.01E+01	No data	3.01E+01
Benzo(k)fluoranthene	3.01E+02	No data	3.01E+02
Benzoic acid	1.00E+05(max)	1.59E+06	No data
Beryllium	1.58E+03	1.58E+03	1.28E+06
α-Benzene hexachloride	6.05E+00	2.84E+02	6.05E+00
β-Benzene hexachloride	2.12E+01	1.14E+02	2.12E+01
g-Benzene hexachloride	2.93E+01	1.70E+02	2.93E+01
1,1-Biphenyl	3.96E+04	3.96E+04	No data
Bis(2-chloroethyl)ether	3.31E+01	No data	3.31E+01
Bis(2-chloroisopropyl)ether	4.45E+02(sat)[e]	2.06E+04	5.20E+02
Bis(2-ethylhexyl)phthalate	1.83E+03	7.97E+03	1.83E+03
Bis(chloromethyl)ether	8.27E-02	No data	8.27E-02
Boron	1.00E+05(max)	1.58E+05	No data
Bromobenzene	2.45E+02(sat)	9.52E+02	No data
Bromodichloromethane	2.61E+02	7.15E+03	2.61E+02
Bromomethane	2.01E+02	2.01E+02	No data
1,3-Butadiene	2.18E+01	3.76E+01	2.18E+01
Butanone[2-]	4.87E+04(sat)	4.03E+05	No data
n-Butylbenzene	6.21E+01(sat)	3.19E+03	No data
sec-Butylbenzene	6.06E+01(sat)	2.66E+03	No data
tert-Butylbenzene	1.06E+02(sat)	3.01E+03	No data
Butyl benzyl phthalate	7.97E+04	7.97E+04	No data

Analyte	Recreational SSL[a] (mg/kg)	Noncarcinogenic SSL (mg/kg)	Carcinogenic SSL (mg/kg)
tert-Butyl methyl ether (MBTE)	7.25E+03	2.59E+05	7.25E+03
Cadmium	3.92E+02	3.92E+02	1.71E+06
Carbazole	1.28E+03	no data	1.28E+03
Carbon disulfide	4.60E+02(sat)	1.45E+04	No data
Carbon tetrachloride	6.88E+01	7.49E+01	6.88E+01
Chlordane	1.09E+02	2.84E+02	1.09E+02
2-Chloroacetophenone	1.03E+00	1.03E+00	No data
2-Chloro-1,3-butadiene	1.67E+02	1.67E+02	No data
1-Chloro-1,1-difluoroethane	2.11E+02(sat)	9.89E+05	No data
Chlorobenzene	2.45E+02(sat)	4.31E+03	No data
1-Chlorobutane	2.99E+02(sat)	3.06E+03	No data
Chlorodifluoromethane	2.11E+02(sat)	9.89E+05	No data
Chloroethane	1.32E+03	1.64E+05	1.32E+03
Chloroform	8.70E+01	1.70E+02	8.70E+01
Chloromethane	4.46E+02	2.32E+03	4.46E+02
β-Chloronaphthalene	5.22E+04	5.22E+04	No data
o-Chloronitrobenzene	3.88E+01	3.88E+01	3.24E+03
p-Chloronitrobenzene	2.30E+02	2.30E+02	4.56E+03
2-Chlorophenol	2.62E+03	2.62E+03	No data
2-Chloropropane	7.05E+02(sat)	6.25E+03	No data
o-Chlorotoluene	2.02E+02(sat)	4.66E+03	No data
Chromium (total)	1.43E+04	1.43E+04	2.57E+05
Chromium(III)	1.00E+05(max)	1.19E+06	No data
Chromium(VI)	2.38E+03	2.38E+03	3.73E+04
Chrysene	3.01E+03	No data	3.01E+03
Cobalt	1.57E+04	1.57E+04	1.10E+06
Copper	3.17E+04	3.17E+04	No data
Crotonaldehyde	1.49E+00	No data	1.49E+00
Cumene (isopropylbenzene)	3.89E+02(sat)	6.89E+03	No data
Cyanide	7.97E+03	7.97E+03	No data
Cyanogen	1.71+03(sat)	3.85E+03	No data
Cyanogen bromide	2.02E+03(sat)	1.27E+04	No data
Cyanogen chloride	2.02E+03(sat)	7.08E+03	No data
p',p'-DDD	1.73E+02	No data	1.73E+02
p'p'-DDE	1.22E+02	No data	1.22E+02
p',p'-DDT	1.22E+02	3.06E+02	1.22E+02
Dibenz(a,h)anthracene	3.01E+00	No data	3.01E+00
Dibenzofuran	1.58E+03	1.58E+03	No data
1,2-Dibromo-3-chloropropane	4.04E+01	4.52E+01	4.04E+01

Analyte	Recreational SSL[a] (mg/kg)	Noncarcinogenic SSL (mg/kg)	Carcinogenic SSL (mg/kg)
Dibromochloromethane	6.73E+02	1.58E+04	6.73E+02
1,2-Dibromoethane	8.90E+00	1.53E+03	8.90E+00
1,4-Dichloro-2-butene	2.11E+00	No data	2.11E+00
1,2-Dichlorobenzene	3.74E+01(sat)	2.24E+03	No data
1,3-Dichlorobenzene	3.74E+01(sat)	7.07E+02	No data
1,4-Dichlorobenzene	7.10E+02	2.05E+04	7.10E+02
3,3-Dichlorobenzidine	5.69E+01	No data	5.69E+01
Dichlorodifluoromethane	2.11E+02(sat)	4.23E+03	No data
1,1-Dichloroethane	1.42E+03(sat)	2.13E+04	No data
1,2-Dichloroethane	1.17E+02	5.10E+02	1.17E+02
cis-1,2-Dichloroethene	8.63E+02(sat)	1.75E+03	No data
trans-1,2-Dichloroethene	1.74E+03(sat)	2.67E+03	No data
1,1-Dichloroethene	9.27E+02(sat)	5.05E+03	No data
2,4-Dichlorophenol	1.20E+03	1.20E+03	No data
1,2-Dichloropropane	1.19E+02	2.23E+02	1.19E+02
1,3-Dichloropropene	2.05E+02	7.17E+02	2.05E+02
Dicyclopentadiene	5.61E+02	5.61E+02	No data
Dieldrin	1.60E+00	1.99E+01	1.60E+00
Diethyl phthalate	1.00E+05(max)	3.19E+05	No data
Dimethyl phthalate	1.00E+05(max)	3.99E+06	No data
Di-n-butyl phthalate	3.99E+04	3.99E+04	No data
Di-n-octyl phthalate	1.59E+04	1.59E+04	No data
2,4-Dimethylphenol	7.97E+03	7.97E+03	No data
1,3-Dinitrobenzene	3.99E+01	3.99E+01	No data
2,4-Dinitrotoluene	7.97E+02	7.97E+02	No data
2,6-Dinitrotoluene	3.99E+02	3.99E+02	No data
2,4 & 2,6 -Dinitrotoluene	3.76E+01	5.98E+02	3.76E+01
Dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin)	2.77E-04	No data	2.77E-04
1,2-Diphenylhydrazine	3.20E+01	No data	3.20E+01
Endosulfan	2.39E+03	2.39E+03	No data
Endrin	1.20E+02	1.20E+02	No data
Epichlorohydrin	3.79E+02	3.79E+02	4.09E+03
Ethyl acetate	2.10E+04(sat)	4.32E+05	No data
Ethyl acrylate	5.22E+01(sat)	No data	5.94E+01
Ethyl chloride	1.42E+03	1.64E+05	1.32E+03
Ethyl ether	1.94E+03(sat)	1.22E+05	No data
Ethyl methacrylate	5.27E+01(sat)	6.98E+03	No data
Ethylbenzene	1.28E+02(sat)	4.03E+04	2.59E+05
Ethylene oxide	3.59E+01	No data	3.59E+01

Analyte	Recreational SSL[a] (mg/kg)	Noncarcinogenic SSL (mg/kg)	Carcinogenic SSL (mg/kg)
Fluoranthene	1.39E+04	1.39E+04	No data
Fluorene	3.17E+04	3.17E+04	No data
Furan	1.32E+02	1.32E+02	No data
Heptachlor	5.69E+00	1.99E+02	5.69E+00
Heptachlor epoxide	2.81E+00	5.18E+00	2.81E+00
Hexachlorobenzene	1.60E+01	3.19E+02	1.60E+01
Hexachloro-1,3-butadiene	7.97E+01	7.97E+01	3.28E+02
Hexachlorocyclopentadiene	2.39E+03	2.39E+03	No data
Hexachloroethane	3.99E+02	3.99E+02	1.83E+03
n-Hexane	3.80E+01(sat)	4.20E+03	No data
HMX (high-melting explosive [also 1,3,5,7-tetranitro-1,3,5,7-tetrazocine])	1.99E+04	1.99E+04	No data
Hydrogen cyanide	5.82E+02	5.82E+02	No data
Indeno(1,2,3-c,d)pyrene	3.01E+01	No data	3.01E+01
Iron	1.00E+05(max)	2.38E+05	No data
Isobutanol	2.26E+04(sat)	1.88E+05	No data
Isophorone	2.69E+04	7.97E+04	2.69E+04
Lead[f]	5.60E+20	5.60E+20	No data
Lead (tetraethyl-)	3.99E-02	3.99E-02	No data
Maleic hydrazide	1.61E+03(sat)	6.91E+04	No data
Manganese	3.69E+04	3.69E+04	No data
Mercury (elemental)	1.00E+05(max)	2.54E+07	No data
Mercury (methyl)	3.99E+01	3.99E+01	No data
Mercury (inorganic)	2.38E+02	2.38E+02	No data
Methacrylonitrile	5.68E+01	5.68E+01	No data
Methomyl	2.10E+03	2.10E+03	No data
Methyl acetate	1.00E+05(max)	5.62E+05	No data
Methyl acrylate	1.57E+02(sat)	2.34E+03	No data
Methyl isobutyl ketone	7.01E+03(sat)	6.03E+04	No data
Methyl methacrylate	2.92E+03(sat)	1.19E+05	No data
Methyl styrene (alpha)	2.17E+02(sat)	2.22E+04	No data
Methyl styrene (mixture)	2.17E+02(sat)	2.50E+03	No data
Methylcyclohexane	7.89E+01(sat)	8.11E+04	No data
Methylene bromide	3.48E+03	3.48E+03	No data
Methylene chloride	2.63E+03(sat)	3.86E+04	3.01E+03
2-Methylnaphthalene	3.17E+03	3.17E+03	No data
Methoxychlor	1.65E+03	1.65E+03	No data
Molybdenum	3.96E+03	3.96E+03	No data
Naphthalene	1.58E+04	1.58E+04	No data
Nickel	1.58E+04	1.58E+04	No data

Analyte	Recreational SSL[a] (mg/kg)	Noncarcinogenic SSL (mg/kg)	Carcinogenic SSL (mg/kg)
Nitrate	1.00E+05(max)	1.26E+06	No data
Nitrite	7.92E+04	7.92E+04	No data
Nitrobenzene	3.12E+02	3.12E+02	No data
Nitroglycerin	1.83E+03	No data	1.83E+03
N-Nitrosodiethylamine	1.71E-01	No data	1.71E-01
N-Nitrosodimethylamine	5.02E-01	6.34E+00	5.02E-01
N-Nitrosodi-n-butylamine	3.03E+00	No data	3.03E+00
N-Nitrosodiphenylamine	5.22E+03	No data	5.22E+03
N-Nitrosopyrrolidine	1.22E+01	No data	1.22E+01
m-Nitrotoluene	5.69E+02(sat)	6.06E+03	No data
o-Nitrotoluene	1.51E+02	6.06E+03	1.51E+02
p-Nitrotoluene	5.69E+02(sat)	6.06E+03	2.04E+03
Pentachlorobenzene	3.19E+02	3.19E+02	No data
Pentachlorophenol	1.17E+02	6.85E+03	1.17E+02
Perchlorate	7.92E+01	7.92E+01	No data
Phenanthrene	1.20E+04	1.20E+04	No data
Phenol	1.00E+05(max)	1.20E+05	No data
Aroclor-1016	2.33E+01	2.33E+01	3.00E+02
Aroclor-1221	1.05E+01	1.58E+01	1.05E+01
Aroclor-1232	1.05E+01	1.58E+01	1.05E+01
Aroclor-1242	1.05E+01	1.58E+01	1.05E+01
Aroclor-1248	1.05E+01	1.58E+01	1.05E+01
Aroclor-1254	6.65E+00	6.65E+00	1.05E+01
Aroclor-1260	1.05E+01	1.58E+01	1.05E+01
n-Propylbenzene	6.21E+01(sat)	3.19E+03	No data
Propylene oxide	2.18E+02	3.91E+03	2.18E+02
Pyrene	2.38E+04	2.38E+04	No data
RDX (research department explosive [also hexahydro-1,3,5-trinitro-1,3,5-triazine])	2.33E+02	1.20E+03	2.33E+02
Selenium	3.96E+03	3.96E+03	No data
Silver	3.96E+03	3.96E+03	No data
Strontium	1.00E+05(max)	4.75E+05	No data
Styrene	1.00E+02(sat)	5.85E+04	No data
1,2,4,5-Tetrachlorobenzene	1.20E+02	1.20E+02	No data
1,1,1,2-Tetrachloroethane	7.49E+02	1.23E+04	7.49E+02
1,1,2,2-Tetrachloroethane	9.64E+01	2.47E+04	9.64E+01
Tetrachloroethene	1.34E+02(sat)	5.70E+03	2.38E+02
Thallium	5.23E+01	5.23E+01	No data
Toluene	2.52E+02(sat)	5.29E+04	No data
Toxaphene	2.33E+01	No data	2.33E+01

Analyte	Recreational SSL[a] (mg/kg)	Noncarcinogenic SSL (mg/kg)	Carcinogenic SSL (mg/kg)
Tribromomethane	7.16E+03	1.58E+04	7.16E+03
1,1,2-Trichloro-1,2,2-trifluoroethane	3.28E+03(sat)	9.10E+05	No data
1,2,4-Trichlorobenzene	8.55E+02(sat)	1.62E+03	No data
1,1,1-Trichloroethane	5.63E+02(sat)	6.31E+04	No data
1,1,2-Trichloroethane	2.24E+02	1.18E+03	2.24E+02
Trichloroethene	1.31E+01	2.08E+02	1.31E+01
Trichlorofluoromethane	9.83E+02(sat)	1.51E+04	No data
2,4,5-Trichlorophenol	3.99E+04	3.99E+04	No data
2,4,6-Trichlorophenol	3.99E+01	3.99E+01	2.33E+03
1,1,2-Trichloropropane	6.10E+02	6.10E+02	No data
1,2,3-Trichloropropane	1.81E+00	1.51E+02	1.81E+00
1,2,3-Trichloropropene	3.21E+01	3.21E+01	No data
Triethylamine	8.62E+02	8.62E+02	No data
1,2,4-Trimethylbenzene	1.52E+03	1.52E+03	No data
1,3,5-Trimethylbenzene	6.92E+01(sat)	6.59E+02	No data
1,3,5-Trinitrobenzene	1.20E+04	1.20E+04	No data
2,4,6-Trinitrotoluene	1.99E+02	1.99E+02	8.53E+02
Uranium	2.38E+03	2.38E+03	No data
Vanadium	7.92E+02	7.92E+02	No data
Vinyl acetate	3.68E+03(sat)	2.78E+04	No data
Vinyl bromide	5.57E+01	1.36E+02	5.57E+01
Vinyl chloride (adult+child)	2.84E+01	1.18E+03	2.84E+01
Vinyl chloride (adult)	5.53E+01	1.19E+03	5.53E+01
m-Xylene	8.20E+01(sat)	6.53E+03	No data
o-Xylene	9.95E+01(sat)	7.23E+03	No data
p-Xylene	1.24E+02(sat)	7.00E+03	No data
Xylenes	8.20E+01(sat)	6.54E+03	No data
Zinc	1.00E+05(max)	2.38E+05	No data

[a] The SSL used is the lower of either the noncarcinogenic and carcinogenic SSLs; if an analyte has both noncarcinogenic and carcinogenic effects, both may be included in the screening assessment.

[b] "No data" indicates that an effect category has not been demonstrated for an analyte.

[c] No toxicity information available; pyrene used as surrogate based on structural similarity (NMED 2003, 081172).

[d] A no risk-based maximum concentration for analytes that exhibit relatively low toxicity. The value presented is the maximum value when the risk-based SSL exceeds this level; the risk-based SSLs are provided in the other columns.

[e] SSL for certain volatile organic compounds above which the chemicals may occur as nonaqueous phase liquids in soil.

[f] The SSL for lead is derived using EPA's IEUBK model (EPA 1994, 059894).

REFERENCES

EPA (U.S. Environmental Protection Agency), February 1994. "Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK)," Version 0.99d, EPA 540-R-93-081, OSWER 9285.7-15-1, Technical Review Workgroup for Lead and Office of Emergency and Remedial Response, Washington, D.C. (EPA 1994, 059894)

NMED (New Mexico Environment Department), November 2003. "LANL's Risk Reduction and Environmental Stewardship (RRES) Remediation Services Project Use of Surrogate Chemicals in Risk Assessments," New Mexico Environment Department letter to D. Gregory (DOE) and G.P. Nanos (LANL) from J. Kieling (NMED), Santa Fe, New Mexico. (NMED 2003, 081172)

Appendix E

Screening Action Levels for Radionuclides

Analyte	Residential SAL (pCi/g)	Industrial SAL (pCi/g)	Recreational SAL (pCi/g)	Construction Worker SAL (pCi/g)
Americium-241	30	180	280	34
Cesium-134	2.4	9.7	87	7.7
Cesium-137	5.6	23	210	18
Cobalt-60	1.3	5.1	46	4.1
Europium-152	2.9	11	100	9.1
Europium-154	2.7	11	95	8.4
Europium-155	110	450	4000	360
Iodine-129	44	1800	3500	580
Manganese-54	5.5	22	200	18
Neptunium-237	2.4	50	170	19
Nickel-63	8900	1.3×10^6	1.8×10^6	3.0×10^5
Plutonium-238	37	240	330	40
Plutonium-239/240[a]	33	210	300	36
Radium-226[b]	5	5	5[c]	5[d]
Radium-228[b]	5	5	5[c]	5[d]
Ruthenium-106	20	83	740	66
Sodium-22	1.6	6.5	58	5.2
Strontium-90	5.7	1900	5600	800
Technetium-99	36	2.8×10^5	6.4×10^5	98000
Thorium-228	2.3	9.8	77	6.8
Thorium-230[b]	5	5	5[c]	5[d]
Thorium-232[b]	5	5	5[c]	5[d]
Tritium	750	4.4×10^5	5.1×10^6	3.2×10^5
Uranium-234	170	1500	3200	220
Uranium-235	17	87	520	43
Uranium-238	86	430	2100	160

[a] Plutonium-239 and plutonium-240 typically are unresolved in laboratory analysis. Screening action level (SAL) values for the two isotopes are identical.

[b] The SAL is the generic soil guideline published in Department of Energy (DOE) Order 5400.5. The value of 5 pCi/g applies to the concentration averaged over the first 15 cm of soil below the surface; for subsequent 15-cm-thick layers the generic soil guideline is 15 pCi/g. If both thorium-230 and radium-226 or both thorium-232 and radium-228 are present and not in secular equilibrium, or if other mixtures of radionuclides occur, refer to DOE Order 5400.5 for guidance.

[c] The value of 5 pCi/g is protective of all possible recreational activities, including situations where enclosed structures may exist on the site to capture radon gas. In topographically constrained areas where structures are not feasible, such as hillsides or drainages, dose-based SALs may be used as follows.

- Radium-226: 55 pCi/g, at 73 yr
- Radium-228: 70 pCi/g, at 2.7 yr
- Thorium-230: 150 pCi/g, at 1000 yr
- Thorium-232: 40 pCi/g, at 140 yr

[d] The SAL for the industrial or residential scenario that will apply following construction, based on the conceptual site model, is used.

Appendix F

Risk-Based Recreational Screening Action Levels

Recreational Screening Action Levels Based on 10^{-5} Cancer Risk (RESRAD Version 6.21)

Radionuclide	Recreational SAL (pCi/g)	Time at which SAL Applies[a] (yr)
Americium-241	660	0.0
Cobalt-60	9.1	0.0
Cesium-134	25	0.0
Cesium-137+D[b]	32	0.0
Europium-152	17	0.0
Europium-154	17	0.0
Europium-155	890	0.0
Tritium	4.4×10^4	0.0
Iodine-129	350	0.0
Manganese-54	97	0.0
Sodium-22	15	0.0
Nickel-63	1.3×10^5	0.0
Neptunium-237+D	90	0.0[c]
Plutonium-238	710	0.0
Plutonium-239[d]	670	0.0
Radium-226+D[e]	5[f]	n/a[g]
Radium-228+D[e]	5[f]	n/a
Ruthenium-106+D	320	0.0
Strontium-90+D	1 000	0.0
Technetium-99	2.8×10^4	0.0
Thorium-228+D	24	0.0
Thorium-230[e]	5[f]	n/a
Thorium-232[e]	5[f]	n/a
Uranium-234	940	1000
Uranium-235+D	120	1000
Uranium-238+D	470	1000[c]

[a] Modeling period is 1000 yr. Soil criteria at other times within the modeling period are higher or equivalent.

[b] Includes contribution of radionuclide progeny.

[c] Actual difference in screening actions levels (SALs) between 0 and 1000 yr is negligible.

[d] Plutonium-239 and plutonium-240 are typically are unresolved in laboratory analysis. The SALs for the two isotopes are identical.

[e] The SAL is the generic soil guideline for release of property published in Chapter 4 (Residual Radioactive Material) of the U.S. Department of Energy (DOE) Order 5400.5. The value of 5 pCi/g applies to the concentration averaged over the first 15 cm of soil below the surface; for subsequent 15-cm-thick layers, the generic soil guideline is 15 pCi/g. If both thorium-230 and radium-226 or both thorium-232 and radium-228 are present and not in secular equilibrium, or if other mixtures of radon-generating radionuclides occur, refer to DOE Order 5400.5 for guidance in establishing soil criteria.

[f] The value of 5 pCi/g is protective of all possible recreational activities, including situations where enclosed structures may exist on the site to capture radon gas. In topographically constrained areas where structures are not feasible, such as hillsides or drainages, risk-based SALs may be used as follows.

- Radium-226: 7.3 pCi/g, at ~ 85 yr
- Radium-228: 10 pCi/g, at ~1 yr
- Thorium-230: 20 pCi/g, at 1000 yr
- Thorium-232: 6 pCi/g, at 20–1000 yr

[g] n/a = Not applicable.

Attachment B: Peer Review Comment Form

Part 1 (Document Manager Completes)

Title: **Human Health Risk-Based Screening Methodology, Revision 2** Doc. Cat N

Reviewer's Name (Print): Kirby Olson Organization: Neptune & Company, Inc.

Comments due: **January 8, 2007** (Date)

Author: **Richard Mirenda** Phone: **665-6953** E-Mail: **rmirend**

Return completed and signed forms to: Saundra Martinez Phone: 5-6771 E-Mail: saundra@la

Part 2 (Reviewer Completes)

Date Received: 12/15/06 Date Review Completed: 1/05/07

Signature & Date (to be signed ONLY upon agreement of comment resolution):

Part 3 (If under time constraints, the Author and Reviewer each sign.) ☐ Not all comments resolved; attach PR Comment For

Author Signature & Date: Kirby S. Olson 1/09/07

Reviewer Signature & Date:

Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
1	general	Document doesn't address how screening is done for water for any of the scenarios. Suggest adding text to section 1 or 2 referencing the other guidance for screening water (LA/Pueblo report or Mortandad report for recreational, Region 6 for groundwater) and/or LANL program that assesses water exposures.	A	Text has been added to section 1.0 and an additional section has been added to section 2.0 that address screening of surface water and groundwater.	

[1]page, section #, paragraph/line [2]A = accept / R = reject

Attachment B: Peer-Review Comment Form

Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
2	p. 1	Text in paragraph 2 says template appendices available from ERSS web page; I was unable to locate them. Will they be accessible through the external web site? In paragraph 4 NMED and Region 6 cited as source for guidance, should also include guidance from EPA HQ (ie, new dermal guidance)	R	Templates are not yet on the web but hopefully will be. I will let everyone know when that happens. Both EPA Region 6 and NMED reference the RAGS Part E document.	
3	p.2	Text in paragraph 4 refers reader to appendix B for examples, please add text clarifying that this refers to the Kd and chemical properties tables in that appendix. Paragraph 5, add reference/basis for 0-1 and 0-10 ft depth intervals for various scenarios	A R	Text has been added. There are no references for the depths. This is an assumption made for each scenario.	
4	p. 3	Paragraph 2, change "the scenario(s) is chosen" to "the decision scenario(s) is chosen". Paragraph 3 change "the applicable and most conservative" to "the most conservative of the applicable"	A	Done.	
5	p.4	Paragraph 1, in the discussion of the UCL include the criteria for choosing the max detected value as the EPC in place of the 95% UCL. Remove hyphens from "meat-ingestion" and "drinking-water"	A R	Text added regarding use of max detect. Hyphens are editor preference and will not be changed.	

[1]page, paragraph, line [2]A = accept / R = reject

Attachment B: Peer-Review Comment Form

Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
6	p. 5	Paragraph 1, suggest moving the first sentence ("Chemical SSLs used....") to the start of the second paragraph. Sentence that starts with "These target levels..." should indicate that NMED target differs from Region 6 only for carcinogens. 2nd Paragraph change..."may be a noncarcinogenic value rather than a carcinogenic value" to may be a carcinogenic value for a chemical for which EPA uses the carcinogenic value". 3rd paragraph discusses values based on max, should mention values based on sat here as well	R A R A	Sentence not moved. Author preference. Text added to clarify. Text is correct as stated. Text added to clarify. Text added about Csat.	
7	p. 6	Paragraph 1, mention that the SALs provided in the appendix are based on RESRAD version 6.23	R	The calculations have not changed and were originally done using 6.21 as stated in derivation document. No change necessary.	
8	p. 7	Under bullet on carcinogens; EPA does use 1E-04 risk for some site remediation decisions (such as RODs), but doesn't use this risk level for screening sites. Text should state that COPCs exceeding NMED target must have some further evaluation beyond screening (even if that evaluation occurs within the risk report itself)	R	Text already states this. No revision necessary.	

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Attachment B: Peer-Review Comment Form

Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
9	p. 9	Paragraph below bullets should address also discuss how to address COPCs with elevated DL in a few samples that constitute only a small proportion of the total site samples	R	Text already states this in a general way. No specifics are necessary. No revision necessary.	
10	p. 10	Paragraph 4, change "no toxicity information is available and a surrogate can be found " to "no toxicity information is available and no surrogate can be found"	A	Text has been changed.	
11	p. 13	Paragraph 1 cites EPA draft dermal guidance from 2001. This dermal guidance was finalized in 2004 as: EPA (U.S. Environmental Protection Agency), July 2004, "Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final," EPA/540/R/99/005, Office of Superfund Remediation and Technology Innovation, Washington, D. C. (EPA 2004, 90800).	A	Citation and reference has been changed.	

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Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
12	p. 15	Paragraph 3, change "particles of this size may be available" to "particles of this size may not be available"; change "a limitation of the model is that it does not" to "The model does not" (vehicle dust was deliberately eliminated for these scenarios because of its small contribution under these exposures, so it's not really a limitation)	A	Done.	
13	p. 17	In Table 1 the cell for the recreational scenario child soil ingestion rate say 1 rh/56 hr, should be 5.6 hr	A	Done.	
14	p. 22	Section 4.1 refers to a 1997 memo on the 15 mrem/yr target dose. Though EPA did concur at that time, they issued a memo in 2000 (accompanying their radionuclide PRGs) indicating that radionuclides need to meet the same risk range as nonradionuclide carcinogens. The 15 mrem/yr dose may exceed the risk range under a residential scenario. That EPA memo is attached for the author's interpretation, as the language is somewhat vague. It would be preferable to avoid reference to EPA concurrence with dose limits.	A	EPA reference deleted. No longer necessary.	

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Attachment B: Peer-Review Comment Form

Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
15	p. 23	In the second paragraph under section 4.2 "radon, and tritium" should be removed from the first sentence (they're not exposure pathways.). Suggest following the existing sentence on the unique exposure pathway for tritium with: "A unique exposure pathway for radon is inhalation of radon gas."	A	Comment is contradictory. State not exposure pathways but suggest including sentence stating radon is a unique exposure pathway. Text changed – second paragraph of section 4.2 now reads just inhalation. Sentence on unique pathway for radon added as well as indication for a resident only in parentheses.	
16	p. 24	In paragraph 3, add text to indicate that indoor radon exposure is only for the residential scenario and reference the row in Table 6 for "fraction of time spent indoors each year"	A	Text added.	
17	p. 24	Section 5 would be a good section to discuss those COPCs LANL assesses somewhat differently from NMED. For example, that chromium is presented as a 1:6 ratio of the two forms, that mercury should use the EPA value for mercury and compounds, and that PCBs should be included as carcinogens as well as noncarcinogens. These conventions aren't currently found in other LANL guidance and should appear somewhere in this document. Section 5 should also be reworded to state that 10% is the numeric criteria used to define "negligible contribution to risks/hazard/dose"; (the current wording makes it appear to be only an example)	R A	Not appropriate for section 5.0. Text added to third paragraph of Chemical SSL text. e.g. changed to i.e. for 10% criteria.	

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Attachment B: Peer-Review Comment Form

Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
18	Appendix B	The example tables don't include an example table of background values (a required table listed on p. A-4). This would be a good table to include here because background values are constant and could be pasted directly from here into reports.	R	Have not been including background table in risk appendix. Not relevant since already identify COPCs in data Review appendix. Can reference this rather than add a table. NMED has not commented on this.	
19	Appendix B	On page B-14 there is text referring to an example table of presentation of risks for sites with multiple scenarios, but the table appears to be missing	R	Table provided. Order of tables redone.	
20	Appendices D-F	These screening levels appear in the other LANL guidance documents, are you sure you want to include them here as well? Including them here instead of referencing the other documents means this document will need updating each time any of the screening levels change.	R	For now will continue to include and update as necessary.	

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Attachment B: Peer Review Comment Form

Part 1 (Document Manager Completes) Da

Title: **Human Health Risk-Based Screening Methodology, Revision 2** Doc. Cat No: I

Reviewer's Name (Print): Patricia Gallegos Organization: Neptune and Co.

Comments due: **January 8, 2007** (Date)

Author: **Richard Mirenda** Phone: **665-6953** E-Mail: **rmirenda@**

Return completed and signed forms to: Saundra Martinez Phone: 5-6771 E-Mail: saundra@lanl.g

Part 2 (Reviewer Completes)

Date Received: 12/15/06 Date Review Completed: 1/05/07

Signature & Date (to be signed ONLY upon agreement of comment resolution):

Part 3 (If under time constraints, the Author and Reviewer each sign.) ☐ Not all comments resolved; attach PR Comment Form to

Author Signature & Date: Patricia Gallegos 1/10/07

Reviewer Signature & Date:

Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
1	10, 4, 11	"...and a surrogate can **not** be found..."		Done	

[1]page, section #, paragraph/line [2]A = accept / R = reject

Attachment B: Peer-Review Comment Form

Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
2	Page 26, 3rd reference citation	The abbreviated citation associated with this full reference citation is not used in the body text of the document. The body text uses DOE 2000, 67513 and it should be updated to DOE/AL 2000, 67513	A	Done	
3	B-6, Note, 2nd line	"Additional columns may be used,"	A	Done	
4	B-11, footnotes a and b	m_3 should be m^3 and 10_{+6} should be 10^{+6}	A	Done	
5	F-1, footnote e	The first two words "The SAL" need to be reduced in size to match the text size of the rest of the sentence.	A	Done	

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Attachment B: Peer-Review Comment Form

Comment #	Location[1]	Reviewer's Comment/Suggestion	A/R[2]	Author's Proposed Revision/Resolution	
6	B-14	It would be helpful to have a footnote for the Dose (mrem/ yr) column that explains how the value is calculated.	R	Any discussion of the calculation should be done in the text is necessary not as a footnote to the table.	

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Reviewer Signatures: (By signing, the reviewer indicates that he/she **reviewed** and **approves** the document.)

Reviewer (Print reviewer's name under title)	Signature	Date
Author RICH MIRENDA	Richard Mirenda	1/24/07
Peer Review Chair KIRBY OLSON	see attached	
Solid Waste Regulatory Compliance (SWRC)		
LANL Legal Reviewer		
DOE/LASO Reviewer		
Project Leader RICH MIRENDA	Richard Mirenda	1/24/07
Program Manager		

Document Catalog Number EP2006-1080 — FOR DOCUMENT

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HUMAN HEALTH RISK-BASED
SCREENING METHODOLOGY, REV 2

1/31/07

RICH MIRENDA

Reviewer Signatures: (By signing, the reviewer indicates that he/she reviewed and approves the document.)

Reviewer (Print reviewer's name under title)	Signature	Date
Author RICH MIRENDA	Richard Mirenda	1/24/07
Peer Review Chair KIRBY OLSON	Kirby S. Olson	1/29/07
Solid Waste Regulatory Compliance (SWRC)		
LANL Legal Reviewer		
DOE/LASO Reviewer		
Project Leader RICH MIRENDA	Richard Mirenda	1/24/07
Program Manager		

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HUMAN HEALTH RISK-BASED SCREENING METHODOLOGY, REV 2

1/31/07

RICH MIRENDA

Document Services Request Form

Request date: 12/07/06

Project Leader: Richard Mirenda

Author: Richard Mirenda

Document title: Human Health Risk-Based Screening Methodology, Revision 2

Document type: Revision

Document audience: LANL

Cost codes: MP5R 06PC 6730

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Note: Document must be provided to editor 1-2 weeks before peer review date.

Document due to requestor: 12/15/06

Regulatory deliverable document: ☐ Yes ☑ No **S-7 Review:** ☑ Yes ☐ No

Legal review: ☐ Yes ☑ No DOE review: ☐ Yes ☑ No **GIS Review:** ☐ Yes ☑ No Data Review: ☐ Yes ☑ No

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Service(s) requested:

- ☑ Writer/Editor ☐ proofread ☑ full ☐ edit hard copy
- ☑ Compositor
- ☐ Illustrator
- ☐ Production

Distribution requirements: (Specify distribution requirements below)

Brief summary of request:

Revision of project guidance on how to conduct risk screening assessments. The revision includes language on land use, calculation of exposure point concentrations, the use of previous reports as templates for future reports, and updated recreational screening levels.

(Document Manager only)

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Compositor: PAMELA
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