Appendix H

Risk Assessments

EXECUTIVE SUMMARY

This appendix presents the results of the human health and ecological risk-screening assessments performed in support of the supplemental remediation and investigation activities conducted in 2006–2007 at the area of elevated radioactivity within Consolidated Unit 21-018(a)-99. The analytical results for the 2006–2007 postexcavation data evaluated in this appendix indicate that the primary objective has been met for the supplemental remediation and investigation at the area of elevated radioactivity within Consolidated Unit 21-018(a)-99: no soil or tuff samples collected after completion of excavation activities have chemical of potential concern (COPC) concentrations that exceed applicable residential soil screening levels for inorganic and organic chemicals or screening action levels for radionuclides.

The total estimated excess cancer risk is approximately 3×10^{-7}, which is less than the New Mexico Environment Department (NMED) target level of 1×10^{-5}. The noncarcinogenic COPC hazard index (HI) is 0.1, which is less than the NMED target level of an HI of 1.0. The total dose is 0.44 millirem per year (mrem)/yr, which is less than the U.S. Department of Energy target dose of 15 mrem/yr. This dose corresponds to a radiological risk of approximately 1×10^{-5}, based on a comparison with U.S. Environmental Protection Agency radionuclide preliminary remediation goals for a residential receptor.

The ecological risk screening eliminated all chemicals of potential ecological concern (COPECs), indicating that no potential risk to terrestrial receptors exists from exposure to residual COPEC concentrations in the area of elevated radioactivity.

In summary, these results support the conclusion that no further investigation or corrective action is warranted at the site.

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H-1.0 INTRODUCTION

This appendix presents the results of the human health and ecological risk-screening assessments performed in support of the 2006–2007 supplemental remediation and investigation activities conducted at the area of elevated radioactivity within Consolidated Unit 21-018(a)-99, located on Delta Prime (DP) Mesa in Technical Area (TA) 21 at Los Alamos National Laboratory (LANL or the Laboratory). Field activities were conducted at the area of elevated radioactivity according to the supplemental investigation work plan (LANL 2007, 097448) and the New Mexico Environment Department's (NMED's) approval with modifications (2007, 098287). The primary objective of the supplemental investigation was to remove all soil and tuff with chemical of potential concern (COPC) concentrations greater than residential screening levels within the area of elevated radioactivity.

Consolidated Unit 21-018(a)-99 consists of four inactive solid waste management units (SWMUs) and one area of concern (AOC) consolidated in 1999 according to their related operational history and their proximity to one another (Figure 1.1-3). The following SWMUs and AOC comprise Consolidated Unit 21-018(a)-99:

- SWMUs 21-018(a) and 21-018(b), the three absorption beds and laundry facility south of DP Road, respectively
- SWMU 21-013(b) and AOC 21-013(g), debris disposal areas south of the absorption beds on the south-facing hillslope of BV Canyon (the canyon located directly below Material Disposal Areas [MDAs] B and V)
- SWMU 21-023(c), a septic system and outfall immediately west of the surface disposal areas and also on the south-facing hillslope of BV Canyon

The current land use for Consolidated Unit 21-018(a)-99 is industrial and is expected to remain industrial for the reasonably foreseeable future. However, the decision scenario for cleanup and the associated risk is a residential scenario.

The risk-screening assessments evaluate COPCs in all soil and tuff confirmation samples in the area of elevated radioactivity that is within SWMU 21-018(a) to the east of absorption bed 2, and the samples were collected after excavation activities were completed.

The main features of the risk-screening assessments for the area of elevated radioactivity are as follows:

- summary of historical operations at the site, site features, historical releases, and contamination sources (sections H-1.1 through H-1.3)
- description of the conceptual site model (CSM) for both human and ecological receptors (section H-3.0)
- comparison of maximum inorganic chemical, organic chemical, and radionuclide COPC concentrations with human health soil screening levels (SSLs) for inorganic and organic chemicals and screening action levels (SALs) for radionuclides (section H-4.0)
- comparison of maximum inorganic chemical, organic chemical, and radionuclide COPC concentrations with ecological screening levels (ESLs) (section H-5.0)
- uncertainty analyses relevant to the risk-screening results (sections H-4.2 and H-5.4)
- conclusions of the risk-screening assessments (section H-6.0)

Potential adverse effects to both human and ecological receptors are evaluated based on exposure to COPCs in all postexcavation (i.e., confirmation) samples collected in the area of elevated radioactivity. The human health risk-screening assessment is based on NMED and U.S. Environmental Protection Agency (EPA) Region 6 guidance (NMED 2006, 092513; EPA 2007, 095866) and compares maximum COPC concentrations in the 2006–2007 postexcavation samples with residential SSLs for inorganic and organic chemicals and residential SALs for radionuclides. The ecological risk-screening assessment is performed in accordance with the methodology presented in "Screening Level Ecological Risk Assessment Methods, Revision 2" (LANL 2004, 087630) and compares maximum COPC concentrations in the 2006–2007 postexcavation samples with ESLs.

H-1.1 Site Background

From 1945 to 1978, TA-21 was used primarily for plutonium research, metal production, and related activities. Since 1978, various administrative and chemical research activities have been conducted at TA-21. In general, the historical operations at Consolidated Unit 21-018(a)-99 included activities related to wastewater treatment and disposal and surface debris disposal. Historical operations at the individual SWMUs and AOC in the consolidated unit are summarized in section H-1.2.

H-1.2 Site Description and Operational History

Consolidated Unit 21-018(a)-99 is located on the south side of DP Road, just west of the main gate to the Laboratory's TA-21 operational facilities, and is currently inactive (Figures 1.1-1, 1.1-2, and 1.1-3). The site consists of four inactive SWMUs and one AOC consolidated in 1999 according to their related operational history as well as their proximity to one another and include the following:

- SWMU 21-018(a) (MDA V)—Three wastewater absorption beds that received effluent from 1945 to 1961, located on the mesa south of the laundry facility: The beds were approximately 30 × 250 ft and 12 ft deep and were connected by gravity-fed overflow pipes. The beds and piping were excavated during the 2005–2006 removal activities.
- SWMU 21-018(b)—A former laundry facility for radioactively contaminated clothing that operated from 1945 to 1961, located immediately south of DP Road and directly north of the absorption beds: Operational from 1945 to 1961, the laundry facility was used to wash personal protective clothing and other reusable cloth items used in both research and production operations involving radioactive materials at TA-21. Wastewater was transported first to a concrete well then to the MDA V absorption beds. The wood portions of the building were decommissioned, decontaminated, and demolished in 1965 and taken to MDA G, where the debris was burned. The concrete foundation and associated piping were bulldozed over the edge of DP Mesa and still remain on the south-facing slope of BV Canyon. This debris was later designated SWMU 21-013(b) and AOC 21-013(g).
- SWMU 21-023(c)—A waste treatment laboratory septic system (tank and drainlines) and outfall that received effluent from 1948 to 1965: The septic tank and inlet are located primarily on the mesa, and the outfall is located on the south-facing hillslope of BV Canyon. The tank was removed in 1965 and taken to MDA G. Trenching activities performed during the 2005–2006 investigation indicated that no additional infrastructure (septic tank, lines, etc.) remained at the site.
- SWMU 21-013(b) and AOC 21-013(g)—A surface disposal area from the 1965 demolition of the laundry facility, consisting of building debris downslope of the absorption beds on the south-facing hillslope of BV Canyon: No clear demarcation exists between the SWMU and AOC. Other debris

on the slope includes asphalt and concrete poured onto the slope before it solidified, broken asphalt, concrete, piping, and miscellaneous building materials. The origin of the additional debris is not documented. AOC 21-013(g) consists of two discarded drainlines and miscellaneous building materials, also of unknown origin. It is not known how long these sites received building debris; however, they did not receive wastes after 1994.

SWMUs 21-018(a) and (b) are located on the mesa top. SWMU 21-013(b) and AOC 21-013(g) are located on the slope leading into BV Canyon. The SWMU 21-023(c) septic system is located primarily on the mesa top; the outfall is located on the slope leading into BV Canyon, west of SWMU 21-013(b) and AOC 21-013(g). The area of elevated radioactivity addressed in this supplemental investigation report is within SWMU 21-018(a), to the east of absorption bed 2. Additional details of the historical operations at Consolidated Unit 21-018(a)-99 are provided in the MDA V investigation report (LANL 2007, 098943).

H-1.3 Historical Releases and Contamination Sources

Historical releases and sources of surface and subsurface contamination at the site are related to the historical operations summarized in section H-1.2. In general, these include the following factors:

- The laundry facility discharged wastewater from washing machines at a rate ranging from 22,710 to 30,280 L (6000 to 8000 gal.) per day, equal to approximately 7.57 million L (2 million gal.)/yr, or 151.4 million L (40 million gal.) of effluent over the operating life of the facility (LANL 1991, 007529, p. 16-222).
- Observations as early as 1946 indicated the absorption beds were not functioning properly, causing large amounts of effluent to pool on the ground surface. Also, effluent was reported to have overflowed absorption bed 3 at one time (Abrahams 1962, 001306, p. 22).
- No releases from the debris material on the south slope were identified.
- No historical information was found regarding the amount of effluent (if any) discharged from the blow-down sump to the drainpipe and subsequently to the surface of DP Mesa from the sanitary septic system.

Additional details of the historical releases and sources of surface and subsurface contamination at Consolidated Unit 21-018(a)-99 are provided in the MDA V investigation report (LANL 2007, 098942).

H-2.0 INVESTIGATION SAMPLING AND COPC DETERMINATION

Investigation and confirmation sampling at the area of elevated radioactivity at Consolidated Unit 21-018(a)-99 were conducted in 2006–2007. A total of 15 soil and rock (tuff) confirmation samples were collected from the area of elevated radioactivity during 2006–2007 after the excavation activities were completed.

For both human and ecological receptors, the area of elevated radioactivity is evaluated as a single exposure area. The human health screening assessment uses analytical data for all 15 samples. The ecological screening assessment uses analytical data only for those samples collected from depths (0-5 ft below ground surface [bgs]) that might result in exposure to ecological receptors (seven samples).

Appendix B summarizes the COPC selection process and provides a complete data summary. Table H-2.0-1 summarizes the COPCs identified in the 2006–2007 postexcavation samples.

Table H-2.0-2 summarizes the COPCs identified in the 2006–2007 postexcavation samples collected from 0 to 5 ft bgs, which were evaluated in the ecological risk assessment.

Congeners of dioxins and furans were detected in two subsurface samples. Table H-2.0-3 presents the maximum detected concentration for each congener. The maximum concentrations are converted to an equivalent concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) by multiplying each concentration by a toxicity equivalency factor (TEF), thus deriving a congener-specific toxic equivalent TCDD concentration (www.who.int/ipcs/assessment/tef_updae/en/index.html). The sum of the TCDD-converted values (called the toxicity equivalency quotient [TEQ]) is compared with the TCDD SSL from EPA Region 6 (EPA 2007, 095866) and ecological TCDD ESL (see sections H-4.1 and H-5.3).

H-3.0 CSM

H-3.1 Receptors and Exposure Pathways

Current and future land uses within Consolidated Unit 21-018(a)-99 are industrial. However, the main objective of all remediation activities performed since 2005 has been to remove infrastructure and environmental media with concentrations of COPCs exceeding residential SSLs for inorganic and organic COPCs and residential SALs for radionuclide COPCs. Therefore, the residential scenario was evaluated as the primary decision scenario for the human health risk assessment.

The potential pathways for human exposure to surface soil and tuff are dermal contact, inhalation of vapors or fugitive dust, incidental soil ingestion, and external irradiation. Pathways from subsurface contamination to potential human receptors are complete only if contaminated soil or tuff is excavated and brought to the surface. The potential pathways are similar to those of a surface soil release (i.e., dermal contact, inhalation of vapors or fugitive dust, incidental soil ingestion, and external irradiation). Surface water is not evaluated in the human health screening assessment because no surface water exists at the site.

For ecological receptors, pathways from subsurface contamination to potential surface-dwelling animals are complete only if contaminated soil or tuff is excavated and brought to the surface. The potential pathways are similar to those of a surface soil release (i.e., dermal contact, inhalation of vapors or fugitive dust, incidental ingestion of soil, root uptake by plants, food web transport, and external irradiation). Pathways from subsurface releases may be complete for plants. Surface water is not evaluated in the ecological screening assessment because no surface water exists at the site.

Weathering of tuff is the only viable natural process that may result in the exposure of receptors to COPCs in tuff; because of the slow rate of weathering expected for tuff, exposure to COPCs in tuff is negligible, although it is included in the assessments.

The potential exposure pathways for the human health and ecological receptors are presented in the CSM diagram (Figure H-3.1-1).

H-3.2 Transport Pathways

The primary mechanisms of contaminant release at the site are related to the historical operations summarized in section H-1.3. Saturation is the primary factor in determining the potential for COPCs to migrate to groundwater. Based on previous investigation results, saturated conditions are not present within Consolidated Unit 21-018(a)-99. Downward migration in the vadose zone is also limited by the lack of both hydrostatic pressure and a source for the continued release of contamination. Without sufficient

moisture and a source, little or no potential migration of materials can occur through the vadose zone to groundwater. Surface and subsurface soil and tuff are the media at the area of elevated radioactivity evaluated in this supplemental investigation report.

H-3.3 Environmental Fate and Transport

The evaluation of environmental fate addresses the chemical processes affecting the persistence of a chemical in the environment, and the evaluation of transport addresses the physical processes affecting mobility along a migration pathway. Transport through soil and tuff depends on soil pH, the precipitation or snowmelt, soil moisture, and soil hydraulic properties. Joints and fractures in the tuff may provide additional pathways for moisture and chemicals to enter the subsurface.

Consolidated Unit 21-018(a)-99 lies on a dry mesa top, approximately 1300 ft above the regional aquifer. Saturated conditions currently do not exist in the soil and tuff beneath Consolidated Unit 21-018(a)-99. Current measurements of the gravimetric water content in the upper 75 ft of the soil column indicate that soil on the mesa is relatively dry, and no evidence of a saturated subsurface zone has been found. Downward migration in the vadose zone is also limited by the lack of both hydrostatic pressure and a source for the continued release of contamination.

The nature and extent of contamination at the area of elevated radioactivity have been defined (Appendix B). The results from the deepest samples collected showed either no detected concentrations of COPCs or low trace-level concentrations of only a few inorganic, organic, and radionuclide COPCs in tuff. Also, no source(s) continue(s) to release contamination into the subsurface beneath the site. Because the vertical extent of contamination has been defined for the area of elevated radioactivity at Consolidated Unit 21-018(a)-99, it is apparent that no migration to groundwater has occurred. The limited extent of contamination is related to the absence of the key factors that contribute to migration, as discussed above.

The NMED guidance (2006, 092513) contains screening levels that consider the potential for contaminants in soil to result in groundwater contamination. These screening levels consider equilibrium partitioning of contaminants among solid, aqueous, and vapor phases and account for dilution and attenuation in groundwater through the use of dilution attenuation factors (DAFs). These DAF SSLs can be used to identify chemical concentrations in soil that have the potential to contaminate groundwater (EPA 1996, 059902). Screening contaminant concentrations in soil against these DAF SSLs do not, however, provide an indication of the potential for contaminants to migrate to groundwater. The assumptions used to depvelop these DAF SSLs include an assumption of uniform contaminant concentrations from the contaminant source to the water table (i.e., it is assumed that migration to groundwater has already occurred). Furthermore, this assumption is inappropriate for cases where sampling has shown that contamination is vertically bounded near the surface and the distance from the surface to the water table is large. For these reasons, screening of contaminant concentrations in soil against the DAF SSLs was not performed.

The best indication of the potential for future contaminant migration to groundwater is the current vertical distribution of contaminants in the subsurface. Most releases at MDA V are historical, having occurred decades ago when the adsorption beds were active. For advective transport of contaminants in water to occur from shallow soil/rock to the regional aquifer in a meaningful time frame (e.g., 100 to 1000 yr), significant vertical migration (e.g., hundreds of feet) should already have occurred. Sampling has shown that this has not happened. The vertical extent of contaminant releases at MDA V (other than contaminants transported in the vapor phase for which SSLs are not applicable), is bounded in the near surface.

Inorganic Chemicals

The physical and chemical factors that determine the distribution of inorganic COPCs within the soil and tuff at the site are the soil-water partition coefficient (K_d) of the inorganic chemicals, the pH of the soil, soil characteristics (such as sand or clay content), and redox potential. The interaction of these factors is complex, but the K_d values can provide a general assessment of the potential for migration through the subsurface: chemicals with higher K_d values are less likely to be mobile than those with lower ones. Table H-3.3-1 presents the K_d values for the inorganic COPCs at the area of elevated radioactivity (NMED 2006, 092513)~~; these values match the K_d values recommended by EPA for the default pH of 6.8 for evaluation of Superfund sites (EPA 1996, 059902) and represent conservative values applicable to a wide range of sites~~. Chemicals with K_d values greater than 40 are not likely to migrate through soil toward the water table (Kincaid et al. 1998, 093270). Based on this K_d criterion, aluminum, antimony, barium, chromium, and nickel have a very low potential for migration to groundwater at Consolidated Unit 21-018(a)-99. K_d values were not available for nitrate and uranium. The nitrate concentrations detected are probably naturally occurring levels, and nitrate extent was defined (Appendix B).

The K_d values for copper and selenium given in Table H-3.3-1 indicate that these inorganic chemicals are relatively immobile in soil. Other factors, besides the K_d values, such as speciation in soil and oxidation/reduction (Eh) potential, also play a role in the likelihood that inorganic chemicals will migrate. Information about the fate and transport properties of inorganic chemicals was obtained from individual chemical profiles published by the Agency for Toxic Substances and Disease Registry (ATSDR) (1997, 056531). The information for these inorganic chemicals is also available from the ATSDR website at http://www.atsdr.cdc.gov/toxprofiles.

Most copper deposited in soil is strongly adsorbed and remains in the upper few centimeters of soil. In general, copper adsorbs to organic matter, carbonate minerals, clay minerals, or hydrous iron and manganese oxides. The soil at the area of elevated radioactivity is close to neutral pH (range from 7.3 to 8.9) and does not exhibit a high rate of leaching for copper. Selenium is not often found in the environment in its elemental form but is usually combined with sulfide minerals or with silver, copper, lead, and nickel minerals. In soil, pH and Eh are determining factors in the transport and partitioning of selenium. In soil with a pH greater than 7.5, selenates, which have high solubility and a low tendency to adsorb onto soil particles, are the major selenium species and are very mobile. The soil pH at the area of elevated radioactivity is generally higher than 7.5, which indicates that selenium may migrate in this soil. Nitrate is detected at naturally occurring concentrations and the extent of nitrate is defined (Appendix B).

Radionuclides

For radionuclides, an examination of K_d values also provides an assessment of whether a radionuclide is likely to be mobile in the subsurface at the area of elevated radioactivity. The K_d values for radionuclide COPCs presented in Table H-3.3-2 are from the Superfund chemical data matrix (EPA 1996, 064708). Radionuclides with K_d values greater than 40 are very unlikely to migrate to groundwater (Kincaid et al. 1998, 093270). Based on K_d values, americium-241, cesium-137, plutonium-238, and plutonium-239 have a very low potential to migrate toward groundwater at the area of elevated radioactivity.

The K_d value of 35 indicates that strontium-90 is relatively immobile in the subsurface. Vertical extent is defined for strontium-90.

Tritium's initial behavior in the environment is determined by the source. If it is released as a gas or vapor to the atmosphere, substantial dispersion can be expected, and the rapidity of deposition is dependent on climatic factors. If tritium is released in liquid form, it is diluted in surface water and is subject to physical dispersion, percolation, and evaporation (Whicker and Schultz 1982, 058209, p. 147). Tritium

concentrations in the subsurface at the area of elevated radioactivity are low (<1 pCi/g), indicating that the area of elevated radioactivity is not a significant source of tritium, although this radionuclide is relatively mobile. Because tritium migrates in association with moisture, the low moisture content of the subsurface limits the potential for tritium to migrate to groundwater.

Organic Chemicals

Table H-3.3-3 presents the physical and chemical properties (organic carbon-water partition coefficient [K_{oc}], logarithm to the base octanol-water partition coefficient [log K_{ow}], and solubility) of the organic COPCs at the area of elevated radioactivity. The physical and chemical properties of organic chemicals are important when evaluating fate and transport. The K_{oc} and solubility values were obtained from either Table B-1 of NMED guidance (2006, 092513), EPA Region 6 (2007, 095866), or the Risk Assessment Information System (RAIS) database (http://rais.ornl.gov/). Log K_{ow} values were obtained from the RAIS database. Other information is presented to illustrate some aspects of the fate and transport tendencies of the COPCs (Ney 1995, 058210).

Water solubility is an important chemical characteristic that indicates the mobility of organic chemicals. The higher the water solubility of a chemical, the more likely it is to be mobile and the less likely it is to accumulate, bioaccumulate, volatilize, or persist in the environment. A highly soluble chemical (water solubility greater than 1000 mg/L) is prone to biodegradation and metabolism that may detoxify the parent chemical. Methylene chloride has a solubility greater than 1000 mg/L. Dichlorobenzene[1,3-], dichlorobenzene[1,4-], and toluene are also soluble in water but to a lesser extent than methylene chloride.

The remaining organic COPCs at the area of elevated radioactivity have solubilities of less than 10 mg/L (i.e., these COPCs are relatively insoluble). The lower the water solubility of a chemical (especially less than 10 mg/L), the more likely it will be immobilized by adsorption. Chemicals with lower water solubilities tend to be more likely to accumulate or bioaccumulate and persist in the environment, are slightly prone to biodegradation, and may be metabolized in plants and animals.

Chemicals with a Henry's law constant greater than 10^{-5} atmosphere m^{-3}/mol and a molecular weight less than 200 g/mol are likely to volatilize; therefore, their concentrations at the site are reduced over time. Vapors of these chemicals are more likely to travel toward the atmosphere and not migrate toward groundwater. The following organic COPCs from the area of elevated radioactivity are likely to volatilize: 1,3-dichlorobenzene; 1,4-dichlorobenzene; methylene chloride; and toluene.

The soil K_{oc} measures the tendency of a chemical to adsorb to organic carbon in soil. K_{oc} values greater than 500 cm^3/g indicate a strong tendency to adsorb to soil (NMED 2006, 092513). Table H-3.3-3 provides the K_{oc} values for organic COPCs at the area of elevated radioactivity. Only three COPCs have K_{oc} values less than 500 cm^3/g: 1,3-dichlorobenzene; methylene chloride; and toluene.

Table H-3.3-3 shows the log K_{ow} for organic COPCs at the area of elevated radioactivity. With the exception of methylene chloride and toluene, all the chemicals have a log K_{ow} greater than 3, indicating that most of the organic COPCs are likely to sorb to soil and are relatively immobile. Extent has been defined for both of these COPCs.

Summary

Saturation is the primary factor in determining the potential for COPCs to migrate to groundwater. Based on investigation results, saturated conditions are not present within the area of elevated radioactivity at Consolidated Unit 21-018(a)-99. Downward migration in the vadose zone is also limited by the lack of

both hydrostatic pressure and a source for the continued release of contamination. Without sufficient moisture and a source, little or no potential migration of materials can occur through the vadose zone to groundwater.

The nature and extent of contamination at the area of elevated radioactivity at Consolidated Unit 21-018(a)-99 are defined, and no source(s) continue(s) to release contamination into the subsurface beneath the site. The lack of saturated conditions and hydrostatic pressure severely limits the movement of contamination toward groundwater at the site. The relative solubilities and/or their partitioning properties also limit the mobility of the COPCs at the site. As a result, the potential for COPC migration to groundwater is very low, based on current site conditions, physical and chemical properties of COPCs (section H-3.3), the distance to the regional aquifer below the site (approximately 1300 ft), and the absence of a source for continued releases into the subsurface.

H-4.0 HUMAN HEALTH RISK-SCREENING ASSESSMENT

A human health risk-screening assessment was conducted to determine whether COPC concentrations in soil and tuff at the area of elevated radioactivity might pose a potential unacceptable risk to human receptors. The assessment assumes residential land use to support corrective action or no further action decisions at the area of elevated radioactivity.

H-4.1 Screening Evaluation

The human health risk-screening assessment compares maximum detected concentrations at the area of elevated radioactivity with residential SSLs for inorganic and organic chemicals and residential SALs for radionuclides. The SSL/SAL comparisons are presented separately for noncarcinogenic chemicals, carcinogenic chemicals, and radionuclides. SSLs for noncarcinogens are based on a hazard quotient (HQ) of 1.0; SSLs for carcinogens are based on a target cancer risk of 10^{-5} (NMED 2006, 092513). Cumulative cancer risk and a hazard index (HI) are also provided for the area evaluated. The ratio of each COPC exposure, calculated as the maximum detected concentration divided by the respective SSL, is the HQ; the sum of all HQs is the HI. The residential chemical SSLs are from NMED guidance (2006, 092513), but if NMED does not have an SSL for a chemical, EPA Region 6 guidance (2007, 095866) or EPA Region 9 values (http://www.epa.gov/region09/waste/sfund/prg/) are used, adjusted to 10^{-5} risk for carcinogens. The SALs for radionuclides are based on a dose of 15 millirem (mrem)/yr and are derived according to Laboratory guidance (2005, 088493).

The maximum detected concentrations for carcinogenic COPCs in the area of elevated radioactivity do not exceed the respective residential SSLs (Table H-4.1-1). The total estimated excess cancer risk is approximately 3×10^{-7}, which is less than NMED's target level of 1×10^{-5} (2006, 092513). The maximum concentrations for the noncarcinogenic COPCs in the area of elevated radioactivity also do not exceed the respective residential SSLs (Table H-4.1-2). The HI for the area of elevated radioactivity is 0.1, which is less than the NMED target level of an HI of 1.0 (2006, 092513). The total dose is 0.44 millirem per year (mrem/yr) (Table H-4.1-3), which is less than the U.S. Department of Energy's (DOE's) target dose of 15 mrem/yr (2000, 067489).

H-4.2 Uncertainty Analysis

The analyses presented in human health risk-screening assessments are subject to varying degrees and types of uncertainty. Aspects of data evaluation and COPC identification, exposure assessment, toxicity assessment, and the additive approach all contribute to uncertainties in the risk assessment process.

H-4.2.1 Data Evaluation and COPC Identification Process

A primary uncertainty associated with the COPC identification process is the possibility that a chemical may be inappropriately identified as a COPC. It is unlikely that inorganic chemicals were inappropriately excluded as COPCs because the only inorganic chemicals excluded were those with concentrations less than the background value or within the range of background concentrations (LANL 1998, 059730). Organic chemicals were appropriately identified as COPCs because all detected organic chemicals were retained for analysis.

Uncertainties associated with the inorganic chemical, organic chemical, and radionuclide data include sampling errors, laboratory analysis errors, and data analysis errors. For the area of elevated radioactivity, these uncertainties have no effect on the results, although detected concentrations of organic COPCs were J-qualified, indicating the values were less than estimated quantitation limits and could only be estimated.

H-4.2.2 Exposure Assessment

The following uncertainties result in a conservative (overestimation) of potential risk to human receptors from COPCs in soil and tuff at the area of elevated radioactivity:

- **Identification of Receptors—**The current and proposed future land use is industrial. However, the primary objective of remediation activities performed in the area of elevated radioactivity was to remove environmental media with concentrations of COPCs exceeding residential SALs for radionuclides or SSLs for inorganic and organic chemicals. Therefore, residential receptors were evaluated as the primary receptors within this risk assessment.
- **Exposure Pathways—**A number of assumptions are made relative to exposure pathways, including input parameters, whether or not a given pathway is complete, the contaminated media to which an individual may be exposed, and intake rates for different routes of exposure. In the absence of site-specific data, the exposure assumptions used were consistent with default values (NMED 2006, 092513). When several upper-bound values (as are found in NMED 2006, 092513) are combined to estimate exposure for any one pathway, the resulting risk can exceed the 99th percentile of "expected risk" and therefore can exceed the range of risk that may be reasonably expected. Also, the assumption that residual concentrations of chemicals in the tuff are available and cause exposure in the same manner as if they were in soil overestimates the potential risk to receptors.
- **Exposure Point Concentrations—**Some uncertainty is introduced in the concentration aggregation of data for estimating the exposure point concentrations (EPCs). Risk from a single location or area with relatively high COPC concentrations may overestimate exposure. The use of the maximum detected concentration is intended to provide an upper-bound (e.g., conservative) COPC concentration at the site, which may lead to an overestimation of exposure to a COPC across the site.
- **Similarity to Background Concentrations—**EPCs for inorganic COPCs may be similar to background concentrations and may therefore overestimate the potential exposure and risk to a receptor.

H-4.2.3 Toxicity Assessment

The primary uncertainty associated with the SSLs is related to the derivation of toxicity values used in their calculation. Toxicity values (slope factors [SFs] and reference doses [RfDs]) were used to derive the

SSLs used in this risk-screening assessment (NMED 2006, 092513). Uncertainties were identified in three areas with respect to the toxicity values, as discussed in this section: extrapolation from animals to humans, extrapolation from one route of exposure to another route of exposure, and individual variability in the human population.

- **Extrapolation from Animals to Humans**—The SFs and RfDs are often determined by extrapolation from animal data to humans, which may result in uncertainties in toxicity values because differences exist in chemical absorption, metabolism, excretion, and toxic responses between animals and humans. Differences in body weight, surface area, and pharmacokinetic relationships between animals and humans are taken into account to address these uncertainties in the dose-response relationship. However, conservatism is usually incorporated into each of these steps, resulting in the overestimation of potential risk.
- **Extrapolation from One Route of Exposure to Another Route of Exposure—**The SFs and RfDs often contain extrapolations from one exposure route to another that result in additional conservatism in the risk calculations. For example, an extrapolation from the oral route to the inhalation and/or the dermal route was used in this assessment (NMED 2006, 092513), and differences between the two exposure pathways contribute to the uncertainty in the estimation of potential risk at this site.
- **Individual Variability in the Human Population—**For noncarcinogenic effects, the degree of variability in human physical characteristics is important both in determining the risks that can be expected at low exposures and in defining the no observed adverse effect level (NOAEL). The NOAEL uncertainty factor approach incorporates a 10-fold factor to reflect individual variability within the human population that can contribute to uncertainty in the risk assessment. This factor of 10 is generally considered to result in a conservative estimate of risk to noncarcinogenic COPCs.

H-4.2.4 Additive Approach

For noncarcinogens, the effects of exposure to multiple chemicals are generally not known, and possible interactions could be synergistic or antagonistic, resulting in either an overestimation or underestimation of the potential risk. Additionally, RfDs used in the risk calculations typically are not based on the same endpoints with respect to severity, effects, or target organs. Therefore, the potential for noncarcinogenic effects may be overestimated for individual COPCs that act by different mechanisms and on different target organs but are addressed additively.

H-4.3 Results of Human Health Screening Analysis

The maximum concentrations for carcinogenic COPCs in the area of elevated radioactivity do not exceed the respective residential SSLs (Table H-4.1-1). The total estimated excess cancer risk is approximately 3×10^{-7}, which is less than NMED's target level of 1×10^{-5} (2006, 092513). The maximum detected concentrations for the noncarcinogenic COPCs in the area of elevated radioactivity also do not exceed the respective residential SSLs (Table H-4.1-2). The HI is 0.1, which is less than the NMED target level of an HI of 1.0 (2006, 092513). The total dose is 0.44 mrem/yr (Table H-4.1-3), which is less than DOE's target dose of 15 mrem/yr (2000, 067489). This dose corresponds to a radiological risk of approximately 1×10^{-5}, based on a comparison with EPA radionuclide preliminary remediation goals for a residential receptor (http://epa-prgs.ornl.gov/radionuclides/download/rad_master_prg_table_pci.xls).

H-5.0 ECOLOGICAL SCREENING ASSESSMENT

An ecological screening assessment was conducted to determine whether COPCs at the area of elevated radioactivity pose a potential unacceptable risk to ecological receptors. The approach used to evaluate ecological risk is described in "Screening Level Ecological Risk Assessment Methods, Revision 2" (LANL 2004, 087630).

H-5.1 Scoping Evaluation

The scoping evaluation establishes the breadth and focus of the ecological screening assessment. The ecological checklist (Attachment H-2 of LANL 2007, 098942) organizes existing ecological information about the site for the scoping evaluation and forms the basis for the determination of key aspects of the CSM: habitat type and quality, potential receptor exposure, and contaminant transport pathways.

The area of elevated radioactivity is highly disturbed and consists primarily of bare soil and rock from the removal actions that have taken place. The dominant overstory vegetation type surrounding the area is ponderosa pine, with minor vegetation components of fir (white and Douglas) and piñon pine. The understory surrounding the site contains mostly native and nonnative grasses and ruderal species indicative of disturbance, with a few shrubs and forbs. The general habitat quality in undisturbed areas surrounding the site is sufficient to support grazing and foraging by terrestrial receptors. However, the habitat within the boundary of the area of elevated radioactivity is of relatively poor quality because of significant disturbance from the removal activities conducted at the site. No threatened and endangered (T&E) species habitat is present at the site.

Surface water runoff terminates to the south-southwest of the site in BV Canyon. The area of elevated radioactivity is located upgradient of the steep slope to the canyon. No potential for exposure to aquatic receptors exists because no persistent aquatic habitat or perennial source of water occurs in the canyon. Additionally, the depth of the regional aquifer (approximately 1300 ft bgs) and the semiarid climate provide for minimal hydrologic head and preclude migration of COPCs to groundwater. Thus, exposure to groundwater is not evaluated in the screening-level ecological assessment for the area of elevated radioactivity.

The potential exposure of terrestrial receptors to COPCs in surface soil and unconsolidated tuff is by root uptake, dust inhalation, soil ingestion, external irradiation, dermal exposure, and food web transport (Figure H-3.1-1). Exposure pathways to receptors from COPCs in consolidated tuff are incomplete because COPCs in tuff are generally immobilized and become available to receptors only as a function of the slow rates of weathering of the tuff. Plant exposure to COPCs in tuff is largely limited to fractures near the surface, which does not produce sufficient biomass to support an herbivore population. Consequently, COPCs in tuff are not available to the extent necessary to cause adverse population-level effects.

Potentially complete pathways for exposure of terrestrial receptors to COPCs exist at the site. The potential risk is evaluated quantitatively in this risk-screening assessment for the following ecological receptors, representing several feeding guilds and trophic levels:

- plants
- soil-dwelling invertebrates (represented by the earthworm)
- deer mouse (mammalian omnivore)
- Montane shrew (mammalian insectivore)
- desert cottontail (mammalian herbivore)

- fox (mammalian carnivore)
- American robin (avian insectivore, omnivore, and herbivore)
- American kestrel (avian insectivore and carnivore); surrogate for avian T&E species

Of the terrestrial receptors evaluated, only the Montane shrew is not expected to be present at the area of elevated radioactivity because it requires free water for survival—surface water does not exist at the site. However, because the shrew represents the insectivorous feeding guild for mammals, which is not specifically represented by any of the other terrestrial receptors, the shrew is evaluated in this risk-screening assessment.

H-5.2 Assessment Endpoints

An assessment endpoint is an "explicit expression of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes" (EPA 1998, 062809). Assessments should include ecologically relevant endpoints that help to sustain the natural structure, function, and biodiversity of an ecosystem or its components. In this screening assessment, the assessment endpoints are the populations and communities of the terrestrial receptors listed in this section, and the assessment is consistent with EPA guidance (1997, 059370).

The screening process is designed to be protective of biotic populations and ecological communities rather than individual organisms, except for "special status species," which include listed or candidate T&E species or treaty-protected species (EPA 1999, 070086). The American kestrel is evaluated as a surrogate for the Mexican spotted owl, a special status avian receptor (listed T&E species) known to live on and near Laboratory property.

In accordance with EPA guidance on assessment endpoints, the Laboratory developed generic assessment endpoints to ensure that valued and ecologically relevant receptors at all levels within a given ecological community are considered in the screening process (LANL 1999, 064137). These endpoints are evaluated by measuring potential impacts to reproduction, growth, and survival that may adversely affect populations. The specific receptors chosen for the screening evaluation represent feeding guilds and thus exposure scenarios for each ecological functional group within the terrestrial communities expected at the site. Receptor species are chosen because of their presence at the site, potential sensitivity to the COPCs, and potential for exposure to those COPCs. In summary, the screening evaluation is designed to protect the selected receptors and other species within the same feeding guilds who occupy similar ecological niches as the selected receptors.

H-5.3 Screening Evaluation

The ecological screening evaluation identifies chemicals of potential ecological concern (COPECs) in soil and tuff from 0 to 5 ft bgs and is based on the comparison of maximum detected concentrations at the site with minimum ESLs. The comparison is summarized in the calculation of HQs for each COPC and screening receptor. The HQ is defined as the ratio of the EPC in the exposure medium being investigated to the concentration that has been determined to be acceptable to a given ecological receptor. The higher the contaminant levels relative to the ESLs, the higher the potential risk to receptors; conversely, the higher the ESLs relative to the contaminant levels, the lower the potential risk to receptors. The analysis begins with a comparison of the minimum ESL with the maximum detected concentration for a given COPC (Table H-5.3-1). COPCs with HQs greater than 0.3 are used to identify COPECs requiring further evaluation (LANL 2004, 087630). COPECs are carried forward in the analysis, and receptor-specific ESLs are compared with the maximum detected concentrations, resulting in an HQ for each

COPEC/receptor combination. Individual HQs for a receptor are summed to derive an HI; an HI greater than 1.0 is an indication of potential adverse impacts to a given receptor from exposure to multiple COPECs at a site. Additionally, chemicals without ESLs are retained as COPECs and are evaluated further in the uncertainty section. The HQ/HI analysis is a conservative indication of potential adverse effects and is designed to minimize the potential of overlooking possible COPECs at the site.

ESLs were obtained from the ECORISK Database, Version 2.2 (LANL 2005, 090032), as presented in Table H-5.3-2, for COPECs requiring further analysis based on the final ESL screen. ESLs are based on similar species and are derived from experimentally determined NOAELs, lowest observed adverse effect levels (LOAELs), or doses determined lethal to 50% of the test population. Information relevant to the calculation of ESLs, including concentration equations, dose equations, bioconcentration factors, transfer factors, and toxicity reference values, are presented in the ECORISK Database, Version 2.2 (LANL 2005, 090032).

Of the COPCs identified for evaluation of ecological risk at the area of elevated radioactivity, four COPCs (methylene chloride, toluene, plutonium-239, and tritium) were eliminated from further evaluation because the minimum ESL analysis indicated that HQs for all receptors were less than 0.3 (Table H-5.3-1). A total of five COPCs (four inorganic chemicals and dioxin/furan congeners evaluated as TCDD TEQ) were identified as COPECs. Nitrate could not be evaluated for any receptor because ESLs are not available (Table H-5.3-1) and was retained as a COPEC. As presented in Table H-5.3-3, the HIs for the terrestrial receptors range from 0.02 (American kestrel, top carnivore) to 86 (plant).

H-5.4 Uncertainty Analysis

This section provides an evaluation of the ecological screening assessment results in the context of assumptions used in the screening process to determine whether the results are ecologically meaningful, indicating potential risk to ecological receptors and requiring additional analysis.

A variety of factors contribute to the uncertainty associated with the ecological screening evaluation. Uncertainty is inherent in all aspects of the risk-screening process, including the estimation of exposure to receptors, the characterization of potential ecological effects related to this exposure, and the final evaluation of potential risk to the receptors. The screening analysis is designed so the uncertainties do not lead to an underestimation of the actual risk to the ecological receptors at the site but rather overestimate the potential risk posed by COPECs. When multiple conservative biases are used, the result is a multiplicative effect on the overestimation of risk. The uncertainties identified for the ecological screening assessment for the area of elevated radioactivity are summarized in this section.

H-5.4.1 Chemical Form

Toxicological data are typically based on the most toxic and bioavailable chemical species of a COPC, conditions not likely to occur in the environment. The inorganic, radiological, and organic COPCs identified for the area of elevated radioactivity are generally not 100% bioavailable (as assumed in the screening evaluation) to receptors in the environment because of numerous factors, including adsorption to matrix surfaces (e.g., soil) and rapid oxidation or reduction changes that render chemical species unavailable to biota. This uncertainty leads to an overestimation of potential risk to ecological receptors.

H-5.4.2 Exposure Assumptions

The following assumptions regarding the exposure for terrestrial receptors lead to an overestimation of potential risk to ecological receptors:

- The vicinity around the area of elevated radioactivity is an active industrial area and has been substantially disturbed by the removal activities at the site. Thus, little of the area is available as habitat for ecological receptors.
- EPCs used in the HQ calculations are the maximum detected concentrations in the soil and/or tuff to a depth of 5 ft, assumed to represent the sitewide concentrations of COPCs at the area of elevated radioactivity.
- Receptors are assumed to ingest 100% of their food and spend 100% of their time at the area of elevated radioactivity.
- COPCs in tuff were included in the analysis, although they are not available to receptors.

In addition, the assessment assumes that the COPECs are distributed uniformly across the site. COPECs detected once or only in a few locations are unlikely to impact a receptor population.

H-5.4.3 Toxicity Values

The HQs were calculated using ESLs that are based on NOAELs as threshold-effect levels; actual risk for a given COPEC/receptor combination occurs at a higher level, somewhere between the NOAEL-based threshold and the threshold based on the LOAEL. Using NOAELs leads to an overestimation of potential risk to ecological receptors. The ESLs are based on laboratory studies requiring extrapolation to wildlife receptors. Laboratory studies are typically based on artificial and maintained populations with genetically similar individuals and are limited to single chemical exposures in isolated and controlled conditions using a single exposure pathway. Wild species are concomitantly exposed to a variety of chemical and environmental stressors, potentially rendering them more susceptible to chemical stress. On the other hand, wild populations are probably more genetically diverse than laboratory populations, making wild populations, as a whole, less sensitive to chemical exposure than laboratory populations. The uncertainties associated with the ESLs may under- or overestimate potential risk.

H-5.4.4 Background Concentrations

The ecological screening is based on the exposure of ecological receptors to contamination to a depth of 5 ft. Table H-5.4-1 presents the EPCs for inorganic COPECs and the range of soil and tuff background concentrations (LANL 1998, 059730). All inorganic COPECs had maximum detected concentrations either within the range of background concentrations or less than or equal to twice the maximum background concentration. Based on the comparison of the maximum detected concentrations and the range of background concentrations, barium, chromium, nickel, and selenium were eliminated as COPECs because exposure is similar to background across the site and is not likely to pose a potential ecological risk.

H-5.4.5 Area Use Factors

In addition to the direct comparison of the EPC with the ESLs, area use factors (AUFs) are used to account for the amount of time that a receptor is likely to spend within the contaminated areas based on the size of the receptor's home range (HR). The AUFs for individual organisms were developed by dividing the size of the site by the HR for that receptor. The area of elevated radioactivity is approximately

0.014 hectare (ha). The HR for the Mexican spotted owl is 366 ha; therefore, the AUF for the Mexican spotted owl is 0.000038 (Table H-5.4-2). Based on the application of the AUF for the Mexican spotted owl to the HI for the carnivorous kestrel (0.02), which is a surrogate for the owl, no potential exists for ecological risk to the Mexican spotted owl (HI = 0.000008).

H-5.4.6 Population Area Use Factors

According to the HI analysis (Table H-5.3-3), all terrestrial receptors, except the red fox, desert cottontail, and American kestrel (top carnivore), had HI values greater than 1.0; the HIs for the robin are approximately 1.0. EPA guidance is to manage the ecological risk to populations rather than to individuals, with the exception of T&E species (1999, 070086). To estimate the spatial extent of the areas inhabited by the wildlife populations, one approach is to assess potential effects on populations at the area of elevated radioactivity.

The population area for each receptor is based on the individual receptor HR and its dispersal distance (Bowman et al. 2002, 073475). Bowman et al. (2002, 073475) estimate that the median dispersal distance for mammals is 7 times the linear dimension of the HR (i.e., the square root of the HR area). If only the dispersal distances for the mammals with HRs within the range of the screening receptors are used, the median dispersal distance becomes 3.6 times the square root of the HR (R^2 = 0.91; Bowman et al. 2002, 073475). If it is assumed that the receptors can disperse the same distance in any direction, the population area is circular and the dispersal distance is the radius of the circle. Therefore, the population area for each receptor is approximately 40 HR.

The area of elevated radioactivity is estimated as 0.014 ha. The population area use factor (PAUF) is calculated by dividing the site area of 0.014 ha by the population area of the receptor (Table H-5.4-2). The resulting value is multiplied by the receptor HI to determine whether a potential impact may occur on the population. The HI values for the plant and earthworm are not adjusted by PAUFs because these receptors do not have HRs from which PAUFs can be calculated.

The adjusted HIs for all ecological receptors are equal to or less than 1.0 (Table H-5.4-3), as adjusted for population area use and inorganic COPECs, with maximum detected concentrations similar to background concentrations.

H-5.4-7 COPECs without ESLs

Nitrate has no ESL for any terrestrial receptor. Nitrate was detected in five of eight samples collected between 0 and 5 ft bgs. The maximum detected nitrate concentration of 2.2 mg/kg is considerably lower than the NMED residential SSL of 100,000 mg/kg, indicating that potential toxicity to nitrate is very low. In addition, nitrate is naturally occurring and the concentrations detected are likely not from a release. Nitrate is eliminated as a COPEC.

H-5.5 Results of Ecological Screening Analysis

Based on the ecological screening assessment for the area of elevated radioactivity at Consolidated Unit 21-018(a)-99, several COPECs were identified. All COPECs were eliminated by analyzing several factors that resulted in HIs that do not indicate a potential risk to receptors.

H-6.0 CONCLUSIONS

The analytical results for the 2006–2007 postexcavation data evaluated in this appendix indicate that the primary objective of the supplemental remediation and investigation at the area of elevated radioactivity within Consolidated Unit 21-018(a)-99 has been met: no soil or tuff samples collected after completion of excavation activities have COPC concentrations that exceed applicable residential SSLs and SALs.

The total estimated excess cancer risk is approximately 3×10^{-7}, which is less than NMED's target level of 1×10^{-5} (2006, 092513). The noncarcinogenic COPC HI is 0.1, which is less than the NMED target level of an HI of 1.0 (2006, 092513). The total dose is 0.44 mrem/yr (Table H-4.1-3), which is less than DOE's target dose of 15 mrem/yr (2000, 067489). This dose corresponds to a radiological risk of approximately 1×10^{-5}, based on a comparison with EPA radionuclide preliminary remediation goals for a residential receptor (http://epa-prgs.ornl.gov/radionuclides/download/rad_master_prg_table_pci.xls).

The ecological risk screening eliminated all COPECs, indicating that no potential risk to terrestrial receptors exists from exposure to residual COPEC concentrations in the area of elevated radioactivity.

In summary, these results support the conclusion that no further investigation or corrective action is warranted at the site.

H-7.0 REFERENCES

The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID number. This information is also included in text citations. ER ID numbers are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

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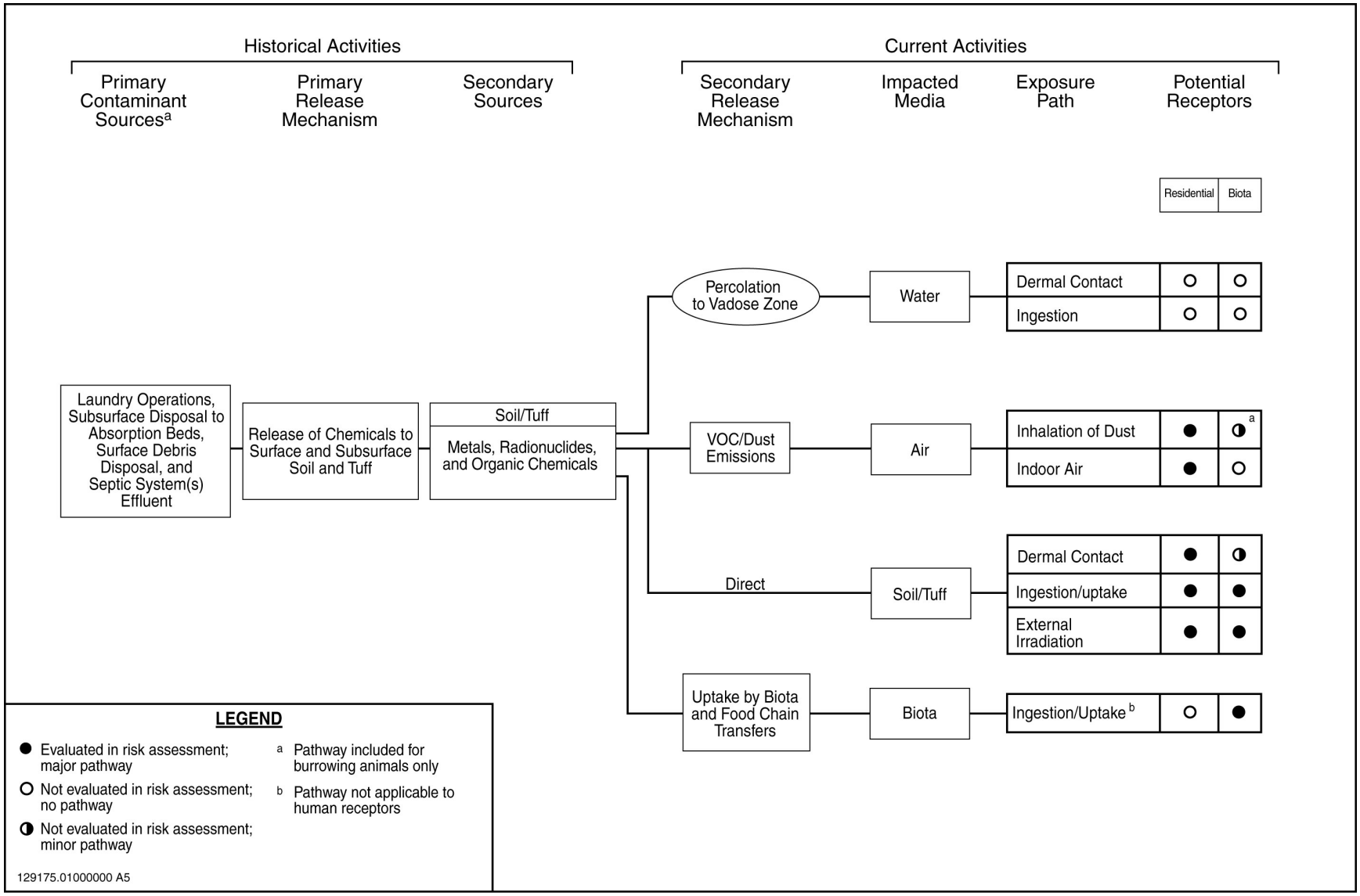

Figure H-3.1-1 CSM flow diagram for Consolidated Unit 21-018(a)-99

Table H-2.0-1
Summary of COPCs Evaluated in Human Health Risk Assessment
for the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

Inorganic COPCs 0–10 ft bgs	Radionuclide COPCs 0–10 ft bgs	Organic COPCs 0–10 ft bgs
Aluminum	Americium-241	Dichlorobenzene[1,3-]
Antimony	Cesium-137	Dichlorobenzene[1,4-]
Barium	Plutonium-238	Fluoranthene
Chromium	Plutonium-239	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]
Copper	Strontium-90	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]
Nickel	Tritium	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]
Nitrate		Hexachlorodibenzodioxin[1,2,3,4,7,8-]
Selenium		Hexachlorodibenzodioxin[1,2,3,6,7,8-]
		Hexachlorodibenzodioxin[1,2,3,7,8,9-]
		Hexachlorodibenzofuran[1,2,3,4,7,8-]
		Hexachlorodibenzofuran[1,2,3,6,7,8-]
		Hexachlorodibenzofuran[2,3,4,6,7,8-]
		Methylene chloride
		Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]
		Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]
		Pentachlorodibenzodioxin[1,2,3,7,8-]
		Pentachlorodibenzofuran[1,2,3,7,8-]
		Toluene

Table H-2.0-2
Summary of COPCs Evaluated in Ecological Risk Assessment
for the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

Inorganic COPCs 0–5 ft bgs	Radionuclide COPCs 0–5 ft bgs	Organic COPCs 0–5 ft bgs
Barium	Plutonium-239	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]
Chromium	Tritium	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]
Nickel		Heptachlorodibenzofuran[1,2,3,4,7,8,9-]
Nitrate		Hexachlorodibenzodioxin[1,2,3,4,7,8-]
Selenium		Hexachlorodibenzodioxin[1,2,3,6,7,8-]
		Hexachlorodibenzodioxin[1,2,3,7,8,9-]
		Hexachlorodibenzofuran[1,2,3,4,7,8-]
		Hexachlorodibenzofuran[1,2,3,6,7,8-]
		Hexachlorodibenzofuran[2,3,4,6,7,8-]
		Methylene chloride
		Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]
		Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]
		Pentachlorodibenzodioxin[1,2,3,7,8-]
		Pentachlorodibenzofuran[1,2,3,7,8-]
		Toluene

Table H-2.0-3
Dioxin/Furan TCDD TEQ Conversions for the
Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPC	TEF	2006–2007 Maximum Concentration (mg/kg)	TEF-Adjusted 2006–2007 Maximum Concentration* (mg/kg)
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	0.01	5.79E-06	5.79E-08
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	0.01	1.06E-06	1.06E-08
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	0.01	1.75E-07	1.75E-09
Hexachlorodibenzodioxin[1,2,3,4,7,8-]	0.1	3.34E-07	3.34E-08
Hexachlorodibenzodioxin[1,2,3,6,7,8-]	0.1	1.49E-06	1.49E-07
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	0.1	1.14E-06	1.14E-07
Hexachlorodibenzofuran[1,2,3,4,7,8-]	0.1	3.38E-07	3.38E-08
Hexachlorodibenzofuran[1,2,3,6,7,8-]	0.1	1.70E-07	1.70E-08
Hexachlorodibenzofuran[2,3,4,6,7,8-]	0.1	2.19E-07	2.19E-08
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	0.0003	2.98E-05	8.94E-09
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	0.0003	3.02E-06	9.06E-10
Pentachlorodibenzodioxin[1,2,3,7,8-]	1	3.27E-07	3.27E-07
Pentachlorodibenzofuran[1,2,3,7,8-]	0.03	3.00E-07	9.00E-09
Total TCDD TEQ (based on maximum detected concentrations)			**7.85E-07**

Source: TEFs from http://www.who.int/ipcs/assessment/tef_update/en/index.html.
Note: TEFs apply to both humans and mammals.
* Adjusted concentrations calculated as (data value) x TEF.

Table H-3.3-1
K_d Values for Inorganic COPCs at the Area of
Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPC	K_d (cm^3/g)
Aluminum	1500
Antimony	45
Barium	41
Chromium[a]	1800000
Copper	35
Nickel	65
Nitrate	na[b]
Selenium	5

Source: K_d values from NMED (2006 092513).
[a] K_d value for chromium(III), the predominant species of chromium, used.
[b] na = Not available.

Table H-3.3-2
K_d Values for Radionuclide COPCs at the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPC	K_d (cm^3/g)
Americium-241	680
Cesium-137	1000
Plutonium-238	4500
Plutonium-239	4500
Strontium-90	35
Tritium*	~~na*~~9.9

Source: K_d values from EPA (1996, 064708).

~~* na = Not available.~~

* Tritium K_d based on tritium gas.

Table H-3.3-3
Chemical Properties of Organic COPCs at the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPCs	K_{oc} (cm^3/g)	Water Solubility (mg/L)	Log K_{ow} (unitless)
Dichlorobenzene[1,3-]	3.80E+01	1.56E+02	3.53E+00
Dichlorobenzene[1,4-]	6.16E+02	7.38E+01	3.44E+00
Fluoranthene	1.07E+05	2.06E-01	5.16E+00
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]*	1.46E+05	2.00E-04	6.80E+00
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]*	1.46E+05	2.00E-04	6.80E+00
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]*	1.46E+05	2.00E-04	6.80E+00
Hexachlorodibenzodioxin[1,2,3,4,7,8-]*	1.46E+05	2.00E-04	6.80E+00
Hexachlorodibenzodioxin[1,2,3,6,7,8-]*	1.46E+05	2.00E-04	6.80E+00
Hexachlorodibenzodioxin[1,2,3,7,8,9-]*	1.46E+05	2.00E-04	6.80E+00
Hexachlorodibenzofuran[1,2,3,4,7,8-]*	1.46E+05	2.00E-04	6.80E+00
Hexachlorodibenzofuran[1,2,3,6,7,8-]*	1.46E+05	2.00E-04	6.80E+00
Hexachlorodibenzofuran[2,3,4,6,7,8-]*	1.46E+05	2.00E-04	6.80E+00
Methylene chloride	1.20E+01	1.30E+04	1.25E+00
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]*	1.46E+05	2.00E-04	6.80E+00
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]*	1.46E+05	2.00E-04	6.80E+00
Pentachlorodibenzodioxin[1,2,3,7,8-]*	1.46E+05	2.00E-04	6.80E+00
Pentachlorodibenzofuran[1,2,3,7,8-]*	1.46E+05	2.00E-04	6.80E+00
Toluene	1.82E+02	5.26E+02	2.73E+00

Sources: K_{oc} and water solubility values from NMED (2006, 092513) unless otherwise noted. Log K_{ow} from RAIS database (http://rais.ornl.gov/cgi-bin/tox/TOX_select?select=nrad).

* Values for TCDD from RAIS database.

Table H-4.1-1
Carcinogenic Screening Evaluation for the
Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPC	Maximum Detected Concentration 0–10 ft bgs (mg/kg)	Residential SSL (mg/kg)	Residential Cancer Risk
Inorganic Chemicals			
Chromium	26	2100[a]	1.24E-07
Organic Compounds			
Dichlorobenzene[1,4-]	0.00019	39.5[b]	4.81E-11
Methylene chloride	0.015	182[b]	8.24E-10
Dioxins/Furans			
TCDD	7.85E-07	3.90E-05[c]	2.01E-07
		Total Excess Cancer Risk	**3E-07**

[a] SSL from EPA Region 6 (2007, 095866) and is corrected to 10^{-5} cancer risk.

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

[c] SSL from EPA Region 6 (2007, 095866) and is corrected to 10^{-5} cancer risk. Dioxin/furan data are adjusted for total TCDD toxicity equivalency in Table H.2.0-3.

Table H-4.1-2
Noncarcinogenic Screening Evaluation for the
Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPC	Maximum Detected Concentration 0–10 ft bgs (mg/kg)	Residential SSL (mg/kg)	Residential HQ
Inorganic Chemicals			
Aluminum	8670	77800	0.11
Antimony	0.15	31.3	0.0048
Barium	286	15600	0.018
Copper	6.64	3130	0.0021
Nickel	6.71	1560	0.0043
Nitrate	2.2	100000	0.00002
Selenium	0.897	391	0.0023
Organic Compounds			
Dichlorobenzene[1,3-]	0.00016	32.6	0.000005
Fluoranthene	0.079	2290	0.00003
Toluene	0.00018	252	0.000001
		HI	**0.1**

Source: SSLs from NMED (2006, 092513) unless otherwise noted.

Table H-4.1-3
Radionuclide Screening Evaluation for the
Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPC	Maximum Detected Concentration 0–10 ft bgs (pCi/g)	Residential SAL (pCi/g)	Residential Dose (mrem/yr)
Americium-241	0.356	30	0.012
Cesium-137	0.096	5.6	0.017
Plutonium-238	0.095	37	0.0026
Plutonium-239	6.76	33	0.20
Strontium-90	1.12	5.7	0.20
Tritium	0.7	750	0.0009
		Total Dose	**0.44**

Source: SALs from LANL (2005, 088493).

Table H-5.3-1
Final ESL Comparisons for the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPC	Maximum Detected Concentration 0–5 ft bgs (mg/kg)	Final ESL (mg/kg)	HQ	Final ESL Receptor
Inorganic Chemicals				
Barium	286	110	**2.6**	Plant
Chromium	26	0.34[a]	**76.5**	Earthworm (invertebrate)
Nickel	6.71	20	**0.34**	Plant
Nitrate	2.2	na[b]	n/a[c]	n/a
Selenium	0.897	0.1	**8.97**	Plant
Organic Compounds				
Methylene chloride	0.015	2.6	0.006	Deer mouse (omnivore)
Toluene	0.00018	23	7.83E-06	Montane shrew (insectivore)
Dioxins/Furans				
TCDD	7.85E-07	2.90E-07	**2.71**	Montane shrew (insectivore)
Radionuclides (pCi/g)				
Plutonium-239	0.097	47	0.002	Earthworm (invertebrate)
Tritium	0.131	36000	3.64E-06	Plant

Source: ESLs from ECORISK Database Version 2.2 (LANL 2005, 090032).
Note: Bold denotes HQ exceeds 0.3.
[a] ESL for hexavalent chromium.
[b] na = Not available.
[c] n/a = Not applicable.

Table H-5.3-2
ESLs for COPECs at the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPEC	ESL (mg/kg)										
	American kestrel (intermediate carnivore)	American kestrel (top carnivore)	American robin (herbivore)	American robin (insectivore)	American robin (omnivore)	Deer mouse (omnivore)	Desert cottontail (herbivore)	Earthworm (invertebrate)	Plant	Montane shrew (insectivore)	Red fox (top carnivore)
Inorganic Chemicals											
Barium	11000	37000	820	1000	930	1800	3300	330	110	1300	41000
Chromium[a]	2200	5400	280	190	220	530	1900	0.34	0.35	170	4400
Nickel	530	9500	530	70	120	530	12000	100	20	250	31000
Selenium	8.5	140	1.5	1.1	1.3	1.1	3	7.7	0.1	0.92	110
Dioxins/Furans											
TCDD	na[b]	na	na	na	na	5.80E-07	4.80E-05	5.00E+00	na	2.90E-07	1.20E-06

Source: ESLs from ECORISK Database Version 2.2 (LANL 2005, 090032).

[a] ESL for hexavalent chromium.

[b] na = Not available.

Table H-5.3-3
HI Analysis for the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPEC	Maximum Detected Concentration 0–5 ft bgs (mg/kg)	HQ										
		American kestrel (intermediate carnivore)	American kestrel (top carnivore)	American robin (herbivore)	American robin (insectivore)	American robin (omnivore)	Deer mouse (omnivore)	Desert cottontail (herbivore)	Earthworm (invertebrate)	Plant	Montane shrew (insectivore)	Red fox (top carnivore)
Inorganic Chemicals												
Barium	286	0.026	0.008	0.349	0.286	0.308	0.159	0.087	0.867	**2.6**	0.22	0.007
Chromium[a]	26	0.012	0.005	0.093	0.137	0.118	0.049	0.014	**76.5**	**74.3**	0.153	0.006
Nickel	6.71	0.013	0.001	0.013	0.096	0.056	0.013	0.001	0.067	0.336	0.027	0.0002
Selenium	0.897	0.106	0.006	0.598	0.815	0.69	0.815	0.299	0.116	**8.97**	0.975	0.008
Dioxins/Furans												
TCDD	7.85E-07	na[b]	na	na	na	na	**1.35**	0.016	1.57E-07	na	**2.71**	0.654
HI		0.1	0.02	**1.1**	**1.3**	**1.2**	**2.4**	0.4	**78**	**86**	**4**	0.7

Note: Bold denotes HQ or HI exceeds 1.0.

[a] ESL for hexavalent chromium.

[b] na = Not available.

Table H-5.4-1
Comparison of Inorganic COPECs to Background Concentrations at the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPEC	Maximum Detected Concentration 0–5 ft bgs (mg/kg)	Range of Soil Background Concentrations (mg/kg)	Range of Tuff Background Concentrations (mg/kg)
Barium	286 (soil)	21–410	n/a*
Chromium	26 (tuff)	n/a	0.25–13
Nickel	6.71 (tuff)	n/a	1–7
Selenium	0.897 (soil)	0.1–1.7	n/a

Source: Background values from LANL (1998, 059730).
* n/a = Not applicable.

Table H-5.4-2
PAUFs for Ecological Receptors at the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

Receptor	HR (ha)	Population Area (ha)	PAUF*
American robin	0.42	16.8	0.00083
Deer mouse	0.077	3.1	0.0047
Montane shrew	0.39	15.6	0.00089

Source: HR areas from EPA (1993, 059384).
* PAUF is calculated as the area of excavation (0.014 ha) divided by the population area.

Table H-5.4-3
COPEC- and PAUF-Adjusted HI Analysis for the Area of Elevated Radioactivity, Consolidated Unit 21-018(a)-99

COPEC	Maximum Detected Concentration 0–5 ft bgs (mg/kg)	American robin (herbivore)	American robin (insectivore)	American robin (omnivore)	Deer mouse (omnivore)	Earthworm (invertebrate)	Plant	Montane shrew (insectivore)
Chromium	26	0.093	0.137	0.118	**0.049**	**76.5**	**74.3**	**0.153**
TCDD	7.85E-07	na[a]	na	na	**1.35**	1.57E-07	na	**2.71**
HI		0.093	0.137	0.118	**1.40**	**76.5**	**74.3**	**2.86**
PAUF-Adjusted HI		7.72E-05	1.14E-04	9.79E-05	0.0066	n/a[b]	n/a	0.025

Note: Bold denotes HQ or HI exceeds 1.0.

[a] na = Not available.

[b] n/a = Not applicable.