ESHID-602581-01

Los Alamos
NATIONAL LABORATORY
EST. 1943

Associate Directorate for Environmental Management
P.O. Box 1663, MS M992
Los Alamos, New Mexico 87545
(505) 606-2337

Environmental Management
P. O. Box 1663, MS M984
Los Alamos, New Mexico 87545
(505) 665-5658/FAX (505) 606-2132

Date: AUG 29 2017
Refer To: ADEM-17-0210
LAUR: 17-27660

John Kieling, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Technical Approach for Calculating Recreational Soil Screening Levels for Chemicals, Revision 5

Dear Mr. Kieling:

Enclosed please find two hard copies with electronic files of the Technical Approach for Calculating Recreational Soil Screening Levels for Chemicals, Revision 5. The report presents the approach Los Alamos National Laboratory uses for calculating recreational soil screening levels (SSLs) for chemicals as well as the revised recreational SSLs. The enclosed document incorporates the latest version of the New Mexico Environment Department's risk assessment guidance as the basis for calculating the recreational SSLs.

If you have any questions, please contact Kent Rich at (505) 665-4272 (krich@lanl.gov) or Arturo Duran at (505) 665-7772 (arturo.duran@em.doe.gov).

Sincerely,

Bruce Robinson, Program Director
Environmental Remediation Program
Los Alamos National Laboratory

Sincerely,

David S. Rhodes, Director
Office of Quality and Regulatory Compliance
Environmental Management
Los Alamos Field Office

BR/DR/KR/:sm

Enclosures: Two hard copies with electronic files – Technical Approach for Calculating Recreational Soil Screening Levels for Chemicals, Revision 5 (EP2017-0125)

Cy: (w/enc.)
Arturo Duran, DOE-EM-LA
Kent Rich, ADEM ER Program

Cy: (w/electronic enc.)
Laurie King, EPA Region 6, Dallas, TX
Steve Yanicak, NMED-DOE-OB, MS M894
emla.docs@em.doe.gov
Public Reading Room (EPRR)
ADESH Records
PRS Database

Cy: (w/o enc./date-stamped letter emailed)
lasomailbox@nnsa.doe.gov
Peter Maggiore, DOE-NA-LA
Kimberly Davis Lebak, DOE-NA-LA
David Rhodes, DOE-EM-LA
Bruce Robinson, ADEM ER Program
Randy Erickson, ADEM
Jocelyn Buckley, ADESH-EPC-CP
Mike Saladen, ADESH-EPC-CP
John Bretzke, ADESH-EPC-DO
Michael Brandt, ADESH
William Mairson, PADOPS
Craig Leasure, PADOPS

LA-UR-17-27660
September 2017
EP2017-0125

Technical Approach for Calculating Recreational Soil Screening Levels for Chemicals, Revision 5

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

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1.0 INTRODUCTION

The chemical soil screening levels (SSLs) used in the human health risk-based screening assessments are based on the current and reasonably foreseeable future land use(s) for a site. Four types of land use can be evaluated: residential, industrial, construction, and recreational. The screening assessments use the SSLs for one or more particular land use/receptors. For residential and recreational scenarios, a child is evaluated for noncarcinogenic effects and an individual from childhood through adulthood for carcinogenic effects that are cumulative over time. Only adult receptors are evaluated for the industrial and construction scenarios.

The SSLs used by the Associate Directorate for Environmental Management (ADEM) have been developed by the New Mexico Environment Department (NMED) for chemicals based on residential, industrial, and construction worker exposures (NMED 2017, 602273, or as updated). If NMED does not have SSLs for a chemical, SSLs from the U.S. Environmental Protection Agency's (EPA's) regional screening tables (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017) are used, adjusted to 1×10^{-5} risk for carcinogens. However, neither NMED nor the EPA has developed recreational SSLs. Recreational SSLs for potential human health risk were originally presented by Los Alamos National Laboratory (LANL or the Laboratory) in 2004 (LANL 2004, 087800); were updated in 2007 (LANL 2007, 094496); and were revised in 2010 (LANL 2010, 108613), 2012 (LANL 2012, 228733), and 2015 (LANL 2015, 600336); and are further revised in this document. The recreational SSLs presented in this document have been updated to reflect new exposure parameters, equations, and toxicity values included in NMED's most recent version of the guidance for developing SSLs (NMED 2017, 602273) and EPA's regional screening tables, available at https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017. For the recreational scenario, the receptors are an adult and a child who walk, hike, or play in Los Alamos County.

The chemical SSLs (for all scenarios) are based on chronic exposure and toxicity and represent the concentration of a chemical associated with either a lifetime excess cancer risk of 1 in 100,000 (1×10^{-5}) for carcinogens or a hazard quotient of 1 for noncarcinogens. These target levels are in agreement with NMED guidance (NMED 2017, 602273) and the June 2016 Compliance Order on Consent. The recreational SSL calculation methodology uses toxicity values and physical and chemical parameters provided in NMED guidance (NMED 2017, 602273) or EPA's regional screening level tables (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017). The information provided in this document includes the exposure parameter values and assumptions used to calculate the recreational SSLs.

The technical approach described in this document is intended to ensure that recreational SSLs are derived in a manner consistent with the methodology described in NMED guidance (NMED 2017, 602273). Any deviations from the procedure described in NMED guidance must have NMED's approval.

2.0 RECREATIONAL SCENARIO

The recreational scenario pertains to individuals who may be exposed as a result of spending a limited amount of time engaged in outdoor activities on or near an area impacted by releases from a solid waste management unit (SWMU) or area of concern (AOC), including time spent in the canyons. Two primary recreational activities are represented by this scenario: an adult trail user/hiker and a child playing outdoors. The child is evaluated under an extended backyard scenario developed to address individual SWMUs and AOCs or canyon areas that are near a residential development and are accessible to pre-teen children for outdoor play. This document expands that scenario to include a 6- to less-than-12-yr-old child walking or playing in a SWMU or AOC or any part of a canyon that is accessible for an extended period of time. For noncarcinogenic chemicals, the duration of the chronic exposure period does not affect the likelihood or severity of adverse health effects. Therefore, the recreational SSLs are based on the child extended backyard exposure scenario because the SSLs for these chemicals are more protective for the child than for the adult trail user. For carcinogenic chemicals, the recreational SSLs are based on the combined exposure duration of the child and the adult trail user because the risk of carcinogenic effects is proportional to the length of the exposure period. If exposure at a SWMU or AOC is expected to be limited to only a child or only an adult, the recreational SSLs may be recalculated to consider only that receptor with proper justification. The exposure pathways evaluated for this scenario include incidental ingestion of soil, inhalation of volatile organic compounds (VOCs) and/or fine soil particles, and skin contact with soil.

The 6-yr to less-than-12-yr age range of the child applied as the receptor under the extended backyard scenario is appropriate given that a child as young as 6 yr of age could potentially walk or play in an unsupervised manner on a SWMU or AOC or in any part of an impacted canyon that is accessible. A younger child is unlikely to do so, is more likely to be supervised by an adult, and would likely experience minimal hours of potential exposure because a younger child is more apt to be carried by an adult at least for part of the time, given he or she has a short attention span or may lack the stamina to walk for any length of time. The 200 d/yr exposure frequency that is used for both child and adult recreational receptors is equivalent to 4 d/wk for 50 wk/yr and is more frequent than a younger child will typically be exposed. It is, therefore, appropriate to conclude the exposure frequency and the age range are representative of the reasonably maximum exposed child for this scenario.

The parameters used to define the exposure under the extended backyard scenario are protective of occasional exposures of a younger child as well. For example, the soil ingestion rate (200 mg/d) is the upper percentile ingestion rate for a 3- to less-than-6-yr-old child (EPA 2011, 208374, Tables ES-1 and 5-1) and is the soil ingestion rate used in NMED (2017, 602273) and EPA (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017) for calculating residential screening levels for a 0- to 6-yr-old child. The central tendency soil ingestion rate for children and young adults of age 1 to less-than-21 yr is 100 mg/d (EPA 2011, 208374, Tables ES-1 and 5-1). The daily time spent outdoors (2.2 h/d) for a 6- to less-than-11-yr-old child is the highest outdoor time for a child less than 12 yr old in any age group and nearly twice the time spent outdoors for a 2- to 3-yr-old child (EPA 2011, 208374, Tables ES-1 and 16-1). For mutagenic chemicals, the soil ingestion rate was biased high relative to residential scenario assumptions by separating the 6- to 16-yr old exposure duration into a 6- to less-than-12-yr-old child and 12- to 16-yr-old adult. In residential calculations, the 6- to 16-yr-old exposure period is treated as an adult exposure, while for recreational it is, in part, evaluated as a child exposure. This change results in soil ingestion pathway risks for mutagenic chemicals that are 2.5 times higher what would have been calculated assigning the 6- to 16-yr-old exposure period to an adult receptor. As mentioned previously, the 200 d/yr recreational exposure frequency is conservatively high and is more frequent than a younger child will typically be exposed. Therefore, the exposure parameters provide protection to a younger child (less than 6 yr old) under the recreational scenario.

3.0 DERIVATION OF RECREATIONAL SSLS FOR CHEMICALS

The toxicity values [reference doses (RfDs), reference concentrations (RfCs), inhalation unit risks (IURs), and slope factors (SFs)] and values for chemical-specific skin absorption (ABS), gastrointestinal absorption (GI_{abs}), and physical parameters are consistent with those provided in NMED guidance (NMED 2017, 602273, Appendixes B and C). For chemicals not included in NMED's guidance for which recreational SSLs were calculated, chemical-specific information was obtained from EPA's regional screening level tables (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017) or, if absent from the EPA tables, from the hierarchy of sources cited in NMED guidance (NMED 2017, 602273).

The recreational SSL for inorganic lead is not derived from the risk equations used for other chemicals because EPA and other federal and state agencies do not publish toxicity values for lead. The recreational lead SSL for a child was calculated using Version 1.1 Build 11 of EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model (https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals). This model can be used to derive soil criteria for exposure of children from birth to 7 yr of age. The recreational SSL for lead is based on a soil lead level that limits exposure of a child to no more than a 5% chance of exceeding a 10 µg/dL blood lead level (EPA 1994, 059509) and includes the contribution of exposures from diet, tap water, and background levels of lead in house dust to total lead exposure. Although the recreational scenario child is defined as between 6 and 12 yr of age, an age group of 4 to 7 yr was protectively assumed in calculating the recreational SSL for inorganic lead. Details on the calculation of the recreational SSL for lead are provided in Appendix B.

3.1 Physical and Chemical Parameters and Toxicity Values

The recommended hierarchy of sources for RfDs, RfCs, IURs, and SFs used in NMED (2017, 602273, Section 2.1) to derive its SSLs is described in EPA guidance (EPA 2003, 086554). The preferred source of toxicity values is EPA's Integrated Risk Information System (IRIS), available 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 Office of Superfund Remediation and Technology Innovation (http://hhpprtv.ornl.gov/quickview/pprtv_papers.php). 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 they (1) reflect the state of knowledge within EPA at the time of their publication and incorporate a level of peer review, and (2) comply with EPA methodologies and practices for developing toxicity values. If provisional values are used in calculating SSLs for chemicals that are potential risk-drivers, the consequences to the confidence of the screening decision may be discussed in the uncertainty analysis of the screening assessment. Lower-tier sources of toxicity values include California EPA's Office of Environmental and Health Hazard Assessment values, New Jersey Department of Environmental Protection, Agency for Toxic Substances and Disease Registry minimal risk levels, and EPA's Health Effects Assessment Summary Table (EPA 1997, 058968). The toxicity information used to calculate the recreational SSLs is provided in the workbook on CD (Appendix C).

Some cancer-causing chemicals operate by a mutagenic mode of action for carcinogenesis. There is reason to surmise that some chemicals with a mutagenic mode of action, which would be expected to cause irreversible changes to the deoxyribonucleic acid (DNA), would exhibit a greater effect in early-life versus later-life exposure. Cancer risk to children in the context of the EPA's carcinogen risk assessment guidelines includes both early-life exposures that may result in the occurrence of cancer during childhood and early-life exposures that may contribute to cancers later in life. Based on this guidance, separate cancer risk equations are presented for mutagens. Equations 1 through 9 (section 3.4) are appropriate for all chemicals, with the exception of those carcinogens exhibiting mutagenic toxicity. Equations 10 through 15 (section 3.4.4) show the derivation of the SSLs for carcinogenic chemicals identified by EPA as potentially exhibiting mutagenic properties.

Chemical-specific physical parameters used in the calculation of SSLs for VOCs include the organic carbon-water partition coefficient for organic compounds (K_{oc}), the soil-water partition coefficient for inorganic constituents (K_d), the solubility of a chemical in water (S), the Henry's law constant (H), air diffusivity (D_a), water diffusivity (D_w), and the chemical's molecular weight. The physical and chemical information is presented in the workbook on CD (Appendix C). A variety of sources for these values is cited in NMED guidance (NMED 2017, 602273), but most citations are from EPA's Estimation Programs Interface (EPI) Suite (https://www.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface) and Water9 Wastewater Treatment Model (http://www.epa.gov/ttn/chief/software/water/index.html) software.

To maintain consistency between the SSLs calculated for the recreational scenario and those published by NMED for other scenarios, the physical and chemical parameters provided in Tables B-1 and B-2 of NMED guidance (NMED 2017, 602273) were used to calculate the recreational SSLs (Appendix D). Physical and chemical parameters for chemicals not included in NMED's SSLs were preferentially obtained from documentation of EPA's regional screening levels (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017) or from the same sources of information cited by NMED for its SSLs.

Since the publication of the most recent NMED SSLs in March 2017, EPA has released an update to its regional screening levels with revised chemical-specific values for toxicity, ABS, and GI_{abs} parameters. Consistent with guidance described in Section 2.1 of NMED guidance (NMED 2017, 602273), these site-specific recreational SSLs employ the most recent values available, which are documented in EPA's regional screening levels (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017). The toxicity values and physical and chemical parameters used to calculate the recreational SSLs are provided on CD (Appendix C). Consistent with current EPA methodology, NMED SSLs and recreational SSLs for chemicals do not employ route-to-route extrapolation of toxicity criteria.

Some chemicals routinely analyzed and detected in environmental media do not have published toxicity values in any of the sources described in the hierarchy above. The approach in these cases is to identify a similar chemical for which toxicity values are available and incorporate it into the screening assessment as a surrogate. The similarity may be based on known or suspected structure-activity relationships or a common degradation pathway to a toxicologically active metabolite. Identification of an appropriate surrogate chemical and whether the evaluation is performed within the context of a screening assessment or a risk assessment is a chemical-specific and assessment-specific decision beyond the scope and purpose of this document.

3.2 Exposure Parameter Values

The exposure parameter values for each of the pathways for the recreational scenario are presented in Table 1. Exposure pathways for chemical SSLs include incidental ingestion of soil, inhalation of volatiles and fugitive dusts, and skin absorption of chemicals present in soil.

The total daily soil ingestion rate for an adult (100 mg/d) is the central tendency soil and dust ingestion rate for ages 6 to less than 21 yr (EPA 2011, 208374, Tables ES-1 and 5-1) and is also the adult value used in NMED guidance (NMED 2017, 602273) and by EPA for calculating regional screening levels (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017). The value of 100 mg/d is twice the recommended adult soil and dust ingestion rate presented in the Exposure Factors Handbook (EPA 2011, 208374, Tables ES-1 and 5-1). The upper percentile estimate of the total daily soil and dust ingestion rate for a child (200 mg/d) is obtained from NMED guidance (NMED 2017, 602273) and EPA guidance (EPA 2011, 208374, Chapter 5, Table 5-1, p. 5-5). When available, the upper percentile daily total soil and dust ingestion values are used to represent reasonable maximum exposure (RME) conditions in this area of the country where vegetation is sparse, winds are prevalent, and incidental soil and dust ingestion may therefore occur to a greater extent than is generally the case in other regions. The child and adult total daily ingestion rates are prorated based upon the ratio of exposure time on-site to the overall time spent outdoors (Appendix A).

Table 1
Recreational Exposure Parameter Values Used in the Recreational SSL Equations

Symbol	Definition	Adult Trail User	Outdoor Child[a]
C	Chemical SSL in soil (mg/kg)		
THQ	Target hazard quotient	1	1
TR	Target cancer risk	10^{-5}	10^{-5}
AT_c	Averaging time (carcinogen)	70 yr × 365 d/yr	
AT_n	Averaging time (noncarcinogen)	ED × 365 d/yr	ED × 365 d/yr
CSF_o	Cancer slope factor–oral	Chemical-specific $(mg/kg\text{-}d)^{-1}$	Chemical-specific $(mg/kg\text{-}d)^{-1}$
IUR	Inhalation unit risk	Chemical-specific $(mg/kg\text{-}d)^{-1}$	Chemical-specific $(mg/kg\text{-}d)^{-1}$
RfD_o	Reference dose–oral	Chemical-specific (mg/kg-d)	Chemical-specific (mg/kg-d)
RfC	Reference concentration–inhalation	Chemical-specific (mg/kg-d)	Chemical-specific (mg/kg-d)
BW	Body weight	80 kg[b]	31 kg[c] (value for male and female)
ED	Exposure duration	26 yr (20 yr for carcinogens)[d]	6 yr (6 to <12 yr of age)
ED_mut	Exposure duration mutagens	28 yr[e]	18 yr[f]
EF	Exposure frequency	200 d/yr	200 d/yr
ET	Exposure time	1 h/d	1 h/d
IRS	Soil ingestion rate	30 mg/d [100 mg/d × (1 h/3.3 h)][g]	91 mg/d [200 mg/d × (1 h/2.2 h)][h]
AF	Adherence factor	0.07 mg/cm^2	0.2 mg/cm^2
GI_{ABS}	Gastrointestinal absorption factor	Default to 1 for most chemicals, chemical-specific for others	Default to 1 for most chemicals, chemical-specific for others
ABS	Skin absorption factor	Semivolatile organic compounds = 0.1. Chemical-specific for others	Semivolatile organic compounds = 0.1. Chemical-specific for others
SA	Exposed surface area	6032 cm^2 (head, hands, forearms, lower legs, feet)	4030 cm^2 (head, hands, forearms, lower legs, feet)[i]
PEF	Particulate-emission factor	6.61×10^9 m^3/kg	6.61×10^9 m^3/kg
VF	Volatilization factor for soil	Chemical-specific (m^3/kg)	Chemical-specific (m^3/kg)

[a] Based on extended backyard scenario.

[b] Adult body weight from NMED (2017, 602273).

[c] Average body weight for a 6- to <11-yr-old child, both genders, from EPA (2011, 208374, Table 8-10).

[d] Exposure duration for lifetime resident from NMED (2017, 602273). For carcinogens, the exposures are combined for child (6 yr) and adult (20 yr) to sum to 26 yr.

[e] Calculated using a mutagenicity adjustment factor of 3 for ages 12 to <16 yr and a factor of 1 for ages 16 to <32 yr (see Equations 11, 13, and 14). Calculated as (4 yr × 3) + (16 yr × 1) = 28 yr.

[f] Calculated using a mutagenicity adjustment factor of 3 for ages 6 to <12 yr (see Equations 11, 13, and 14). Calculated as 6 yr × 3 = 18 yr.

[g] Assumes 1 h of trail use per day, with potential exposure to contaminants occurring over all of that time out of an average of 3.3 h spent outdoors per day for an adult (12 to <32 yr) (EPA 2011, 208374, Table 16-1, p. 16-58). See Appendix A for more details.

[h] Assumes 1 h of trail use per day, with potential exposure to contaminants occurring over all of that time out of an average of 2.2 h spent outdoors per d for a 6- to <12-yr-old child (EPA 2011, 208374, Table 16-1, p. 16-58). See Appendix A for more details.

[i] The exposed skin surface area for this child receptor was calculated using the body-part-specific skin surface area fractions for ages 6, 8, 10 and 12 yr given in Tables 7-8 and 7-9 of EPA (2011, 208374) and total mean body surface area in Tables 7-10 and 7-11 of EPA (2011, 208374). See Appendix A for more details.

The exposure parameter values presented for evaluating dermal absorption of chemicals from soil are based on the values and references provided in NMED guidance (NMED 2017, 602273). The values of child and adult soil adherence factors (AFs) used by NMED (2017, 602273) and shown in Table 1 are from EPA (EPA 2004, 090800). The values of exposed skin surface area (SA) for 0- to 6-yr-old children and adults used by NMED (2017, 602273) are from information presented in Exposure Factors Handbook (EPA 2011, 208374, Chapter 7). The SA values for children and adults used by NMED (2017, 602273) assume soil contact with the head, hand, forearms, lower legs, and feet. The adult exposed skin surface area value of 6032 cm^2 used by NMED (2017, 602273) is also applied to the adult recreational receptor. The exposed skin surface area value for children age 6 to less than 12 yr in the recreational scenario (4030 cm^2) is calculated assuming soil contact with the same body parts using information presented in Exposure Factors Handbook (EPA 2011, 208374, Chapter 7). The input values and calculation for child exposed skin surface area are presented in Appendix A.

Assumptions were made with respect to exposure time (1 h/d) and exposure frequency (200 d/yr) for the recreational RME values. The exposure time represents the total amount of time spent walking per day (90^{th} percentile) in the western U.S. for all age groups (EPA 2011, 208374, Chapter 16, Table 16-26, p. 16-75). The exposure frequency is based on best professional judgment and is equivalent to 4 d/wk for 50 wk/yr. The daily time spent outdoors for a 6- to less-than-11-yr-old child (2.2 h/d) is taken from EPA's Exposure Factors Handbook (EPA 2011, 208374, Tables ES-1 and 16-1). For adults, a weighted average for time spent outdoors (3.3 h/d) was calculated for a 20-yr exposure duration (ages 12 to less than 32 yr) (EPA 2011, 208374, Tables ES-1 and 16-1).

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 VOCs in site soil is calculated using a steady-state volatilization model. The model used is Hwang and Falco's volatilization factor (VF) model, originally described by EPA (1991, 058234). The version of the VF model used to calculate NMED SSLs and Laboratory recreational SSLs is presented in the user's guide and technical background document of EPA's soil screening guidance documents (EPA 1996, 059902) and in NMED guidance (NMED 2017, 602273). VOC status for calculating recreational SSLs was based on the definition provided in section 3.1 of NMED guidance (NMED 2017, 602273) (i.e., those chemicals having a Henry's law constant greater than 10^{-5} atm-m^3/mole-°K and a molecular weight less than 200 g/mole).

The VF model is valid when a VOC is present at soil concentrations below that at which all three components of soil (particulate, pore water, and pore air) are saturated. For conditions in which soil is saturated with one or more organic chemicals, an SSL calculated using the VF model output is not reliable. Both NMED guidance (NMED 2017, 602273) and EPA guidance (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017) recommend the same protocol for establishing SSLs when an SSL for a VOC calculated using the VF model exceeds the saturation value (C_{sat}). For VOCs that are solids at ambient soil temperatures, the SSL is computed using only the soil ingestion and skin absorption exposure pathways if the SSL calculated using the VF model exceeds the value of C_{sat}. For liquid VOCs that have an SSL calculated using the VF model that exceeds the value of C_{sat}, the C_{sat} value is used as the SSL. However, the C_{sat} value for liquid phase VOCs is not analogous to a risk-based screening level based on health effects endpoints; it is used to identify the possible presence of nonaqueous phase VOCs with a greater likelihood of off-site migration. The SSLs presented in Appendix D include the contribution of inhalation pathway risks for VOCs even in cases where the VOC is a solid at ambient soil temperature or where the SSL exceeds the C_{sat} value. The SSLs are footnoted to indicate whether the SSL for a VOC exceeds the C_{sat} concentration or if it is a solid at ambient soil temperatures.

The VF and C_{sat} model equations and parameter values for SSL calculations are documented in Equations 6 and 7 and in Tables 2 and 3, respectively. Parameter values for site-related factors such as water-filled and air-filled soil porosities, soil particle and bulk densities, and amount of soil organic carbon are the default values recommended in NMED guidance (NMED 2017, 602273). Chemical-specific parameter values are required for chemical diffusivity in air and water, Henry's law constant, solubility in water, and organic carbon partition coefficient. The values used in calculating recreational SSLs are the same as those used in NMED guidance to calculate SSLs for residential and industrial exposures (NMED 2017, 602273). The sources used to obtain these values for additional chemicals not included in NMED's SSLs are described in section 3.1.

3.3.2 Inhalation—Fugitive Dust

The concentration of dust suspended in air above contaminated soil and sediment is calculated using EPA's particulate-emission factor (PEF) model, which is a screening-level soil resuspension model. This model was originally described in "Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites" (EPA 1985, 059903). The version of the PEF model used to calculate recreational SSLs is consistent with NMED guidance for residential and industrial exposures (NMED 2017, 602273).

The PEF model used for screening the dust inhalation pathway is from wind erosion of surfaces that have an unlimited reservoir of particles. The model calculates the long-term concentration of respirable particles in the breathing zone as a result of wind erosion. Depending on site soil conditions, an unlimited supply of particles of this size may not be available throughout the exposure period and may overestimate the intake by dust inhalation. The PEF model equations and parameter values for SSL calculations are presented below (Equation 8; Table 4). Parameter values for the PEF model, including the air dispersion term (Q/C), fraction of vegetative ground cover, and wind speed, are default values recommended in NMED guidance for residential and industrial exposures (NMED 2017, 602273).

3.3.3 Dermal Absorption

The amount of soil residing on a unit area of skin is described using an AF. A layer of soil is assumed to cover 100% of a specified body surface area corresponding to the AF. The literature on AFs recognizes that AFs are dependent upon body part, soil type, particle size, soil moisture content, and other variables. Because information for quantifying these variables is often not available, single default values are used for the AFs when SSLs are calculated (0.2 mg/cm^2 for a child and 0.07 mg/cm^2 for an adult) (NMED 2017, 602273).

Skin absorption of a chemical from soil is evaluated using an ABS to model desorption of a chemical from soil, absorption through skin, and transfer to the bloodstream. Consistent with NMED guidance (NMED 2017, 602273) and EPA guidance (EPA 2004, 090800), a default ABS value of 0.1 is used for semivolatile organic compounds. To correct for the influence of incomplete gastrointestinal absorption in an oral toxicity value that is applied to assess dermal pathway risks, chemical-specific GI_{ABS} values are used as a modifier on the oral toxicity values. A protective default value of 1 is used unless a chemical-specific value is available in NMED guidance (NMED 2017, 602273) or EPA regional screening level tables (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017). ABS and GI_{ABS} values from Table B-2 of NMED guidance (NMED 2017, 602273) or EPA regional screening level tables (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017) are used in calculating the recreational SSLs.

3.4 SSL Equations and Parameter Values

Exposure equations for the recreational SSL calculations are provided in Equations 1 to 5. The risk assessment equations are consistent with the calculation of residential SSLs by NMED; only the exposure parameter values were changed to reflect recreational rather than residential exposure. Equations 1 through 3 are used to calculate recreational SSLs for noncarcinogenic effects through direct soil ingestion, inhalation of volatiles and fugitive dusts, and skin absorption from soil. Equations 4 through 6 are used to calculate recreational SSLs for carcinogenic effects. Table 1 gives the parameter values for Equations 1 through 6.

3.4.1 Exposures for Noncarcinogenic Chemicals in Soil

$$C\,(\text{soil ingestion}) = \frac{THQ \times RfD_o \times BW_c \times AT_n}{EF \times ED_c \times \dfrac{IRS_c}{10^6\ \text{mg/kg}}}$$ **Equation 1**

$$C\,(\text{inhalation}) = \frac{THQ \times RfC \times AT_n \times 24\,hr/day}{EF \times ED_c \times ET_c \times \dfrac{1}{(\text{VF or PEF})}}$$ **Equation 2**

$$C\,(\text{dermal}) = \frac{THQ \times RfD_o \times GI_{ABS} \times BW_c \times AT_n}{EF \times ED_c \times \dfrac{SA_c \times AF_c \times ABS}{10^6\ \text{mg/kg}}}$$ **Equation 3**

Note: VF used for volatile chemicals and PEF used for all other chemicals.

where THQ is the target hazard quotient

AT_n is the averaging time for noncarcinogens

EF is the exposure frequency

RfD_o is the oral reference dose

RfC is the inhalation reference concentration

GI_{ABS} is the gastrointestinal absorption factor

ABS is the skin-absorption factor

BW_c, ED_c, IRS_c, SA_c, AF_c, and ET_c are the child exposure parameters for body weight, exposure duration, soil ingestion rate, skin surface area, soil adherence factor, and exposure time, respectively

VF is the volatilization factor

PEF is the particulate-emission factor

3.4.2 Exposures for Carcinogenic Chemicals in Soil

$$C\,(\text{soil ingestion}) = \frac{TR \times AT_c}{CSF_o \times EF \times \dfrac{IFS_{adj}}{10^6\ \text{mg/kg}}}$$ **Equation 4**

$$C\,(\text{inhalation}) = \frac{TR \times AT_c \times 24\text{hr/day}}{IUR \times 1000 \times EF \times ED \times ET \times \frac{1}{(VF \text{ or } PEF)}}$$ **Equation 5**

$$C\,(\text{dermal}) = \frac{TR \times AT_c}{CSF_o / GI_{ABS} \times EF \times \frac{ABS \times SFS_{adj}}{10^6\,\text{mg/kg}}}$$ **Equation 6**

Note: VF used for volatile chemicals and PEF used for all other chemicals.

where TR is the target cancer risk

AT_c is the averaging time for carcinogens

EF is the exposure frequency

ED is the exposure duration

ET is the exposure time

IFS_{adj} is the age-adjusted soil ingestion factor

SFS_{adj} is the age-adjusted skin contact factor

GI_{ABS} is the gastrointestinal absorption factor

ABS is the skin-absorption factor

CSF_o is the oral cancer slope factor

IUR is the inhalation unit risk factor

VF is the volatilization factor

PEF is the particulate-emission factor

Because contact rates may be different for children and adults, carcinogenic risks during the 26-yr exposure period are calculated using age-adjusted factors (Equations 7 and 8). Age-adjusted factors are especially important for soil ingestion exposures, which are higher during childhood and decrease with age. However, for purposes of combining exposures across pathways, an additional age-adjusted factor is used for skin 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 a condition exists, SSLs may be calculated for the individual receptor with proper justification. Table 1 gives the parameter values for Equations 7 and 8.

Equation 7 (mg-yr)/(kg-d) is used for ingestion:

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{(ED_r - ED_c) \times IRS_a}{BW_a}$$ **Equation 7**

Equation 8 (mg-yr)/(kg-d) is used for skin contact:

$$SFS_{adj} = \frac{ED_c \times AF_c \times SA_c}{BW_c} + \frac{(ED_r - ED_c) \times AF_a \times SA_a}{BW_a}$$ **Equation 8**

where IFS_{adj} is the age-adjusted soil ingestion factor

SFS_{adj} is the age-adjusted skin contact factor

ED_r is the recreational exposure duration (26 yr)

ED_c, IRS_c, BW_c, AF_c, and SA_c are the child exposure parameters for exposure duration, soil ingestion rate, body weight, soil adherence factor, and skin surface area, respectively

IRS_a, BW_a, AF_a, and SA_a are the adult exposure parameters for soil ingestion rate, body weight, soil adherence factor, and skin surface area, respectively

3.4.3 Combined Exposures for Chemicals in Soil

The SSL for combined exposures from all pathways is calculated as

$$C\,(\text{combined}) = \frac{1}{1/C_{ing} + 1/C_{inh} + 1/C_{dermal}}$$ **Equation 9**

where C is the concentration for combined exposures

C_{ing} is the concentration for soil ingestion

C_{inh} is the concentration for inhalation

C_{dermal} is the concentration for skin exposure

3.4.4 Equations for Carcinogens Acting by a Mutagenic Mode of Action

Because exposure to mutagenic chemicals may pose particularly high cancer risk for infants and young children when exposures occur, EPA has developed guidance to adjust cancer potency estimates for childhood exposures for carcinogens that have a mutagenic mode of action. Equations 10 through 12 are used to calculate recreational SSLs for mutagenic chemicals. The equations have been modified for the recreational scenario to include the 6 to less-than-12 yr old as a child and the 12 to 16 yr old as an adult rather than a 6 to 16 yr old as an adult in NMED guidance (2017, 602273) and EPA guidance (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017). The mutagenicity adjustment factor for ages 6 to 16 yr is 3. These guidance documents also contain separate equations for the mutagen vinyl chloride, for which EPA has published oral and inhalation SFs applicable to lifetime exposure beginning at birth. However, the age range of the recreational scenario child receptor (6 to less than 12 yr) begins well past birth and lies largely outside the age range of a child (0 to 6 yr) that NMED and EPA guidance apply in their vinyl chloride equations. Therefore, vinyl chloride cancer potency estimates for the child receptor in the recreational scenario are adjusted using the same equations as for other mutagens.

$$C\,(\text{soil ingestion}) = \frac{TR \times AT_c}{CSF_o \times EF \times IFSM_{adj} \times 10^{-6}}$$ **Equation 10**

Equation 11

$$C\,(\text{inhalation}) = \frac{TR \times AT_c}{(EF \times ET \times 1000) \times [(ED_{6\text{-}<12} \times IUR \times 3) + (ED_{12\text{-}16} \times IUR \times 3) + (ED_{16\text{-}<32} \times IUR \times 1)] \times \left(\frac{1}{VF}\ or\ \frac{1}{PEF}\right)}$$

$$C\,(\text{dermal}) = \frac{TR \times AT_c}{\frac{CSF_o}{GIABS} \times EF \times DFSM_{adj} \times ABS \times 10^{-6}}$$ **Equation 12**

Note: VF used for volatile chemicals and PEF used for all other chemicals.

where TR is the target cancer risk

AT_c is the averaging time for carcinogens

EF is the exposure frequency

$ED_{6-<12}$ is the child exposure duration from 6 to <12 yr

ED_{12-16} is the adult exposure duration from 12 to 16 yr

$ED_{16-<32}$ is the adult exposure duration from 16 to <32 yr

ET is the exposure time

$IFSM_{adj}$ is the age-adjusted soil ingestion factor mutagens

$DFSM_{adj}$ is the age-adjusted skin contact factor mutagens

GIABS is the fraction absorbed in gastrointestinal tract

ABS is the skin-absorption factor

CSF_o is the oral cancer slope factor

IUR is the inhalation unit risk factor

VF is the volatilization factor

PEF is the particulate-emission factor

As noted above for other carcinogenic chemicals, contact rates may be different for children and adults. Mutagenic cancer risks are also calculated using age-adjusted soil ingestion and skin absorption factors (Equations 13 and 14). The equations have been modified to include the 6 to less than 12 yr old as a child and the 12 to 16 yr old as an adult rather than a 6 to 16 yr old as an adult.

Equation 13 is used for ingestion:

$$\mathrm{IFSM_{adj}} = \frac{ED_{6-<12} \times \mathrm{IRS_c} \times 3}{\mathrm{BW_c}} + \frac{ED_{12-16} \times \mathrm{IRS_a} \times 3}{\mathrm{BW_a}} + \frac{ED_{16-<32} \times \mathrm{IRS_a} \times 1}{\mathrm{BW_a}} \qquad \textbf{Equation 13}$$

Equation 14 is used for skin contact:

Equation 14

$$\mathrm{DFSM_{adj}} = \frac{\mathrm{ED_{6\text{-}<12}} \times \mathrm{AF_c} \times \mathrm{SA_c} \times 3}{\mathrm{BW_c}} + \frac{\mathrm{ED_{12\text{-}16}} \times \mathrm{AF_a} \times \mathrm{SA_a} \times 3}{\mathrm{BW_a}} + \frac{\mathrm{ED_{16\text{-}<32}} \times \mathrm{AF_a} \times \mathrm{SA_a} \times 1}{\mathrm{BW_a}}$$

where $ED_{6-<12}$ is the child exposure duration from 6 to <12 yr

ED_{12-16} is the adult exposure duration from 12 to 16 yr

$ED_{16-<32}$ is the adult exposure duration from 16 to <32 yr

BW_c is the child body weight

BW_a is the adult body weight

IRS_c is the child soil ingestion rate

IRS_a is the adult soil ingestion rate

SA_c is the child surface area

SA_a is the adult surface area

AF_c is the child soil adherence factor

AF_a is the adult soil adherence factor

$IFSM_{adj}$ is the age-adjusted soil ingestion factor mutagens

$DFSM_{adj}$ is the age-adjusted skin contact factor mutagens

In practice, the calculation of $IFSM_{adj}$ (Equation 13), $DFSM_{adj}$ (Equation 14), and C (inhalation) (Equation 11) can be accomplished using an adjusted exposure duration (ED) term that incorporates the mutagenicity adjustment factor of three. In this simplification, the latter two terms of these equations, including $ED_{12\text{-}16}$ and $ED_{16\text{-}<32}$, are reduced to a single term with an adjusted adult ED. The adjusted child and adult ED values are shown in Table 1.

The mutagen SSL for combined exposures from all pathways is calculated as per Equation 15.

$$\mathrm{C\,(combined)} = \frac{1}{1/C_{\text{mu-ing}} + 1/C_{\text{mu-inh}} + 1/C_{\text{mu-dermal}}}$$ **Equation 15**

3.5 Derivation of the VF

Equation 16 is used to derive the VF for VOCs; the parameters are presented in Table 2.

$$VF_s = \left(\frac{Q}{C}\right) \times \frac{\left(3.14 \times D_A \times T\right)^{1/2}}{2 \times \rho_b \times D_A} \times 10^{-4}\left(m^2/cm^2\right)$$ **Equation 16**

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

3.6 Derivation of the Soil Saturation Concentration

Equation 17 is used to derive the C_{sat} for organic chemicals; the parameters are presented in Table 3.

$$C_{sat} = \frac{S}{\rho_b}\left(K_d \rho_b + \Theta_w + H'\Theta_a\right)$$ **Equation 17**

3.7 Derivation of the PEF

Equation 18 is used to derive the PEF for non-VOCs and inorganic chemicals; the parameters are presented in Table 4.

$$PEF\left(m^3/kg\right) = \frac{Q}{C} \times \frac{3{,}600\,sec/h}{0.036 \times (1 - V) \times \left(U_m/U_t\right)^3 \times F(x)}$$ **Equation 18**

Table 2
Parameters Used to Derive the VF

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

*H' = Henry's law constant ÷ (universal gas constant × absolute temperature).

Table 3
Parameters Used to Derive the Soil Saturation Concentration

Symbol	Definition	Value (Unit)
C_{sat}	Soil-saturation concentration	Chemical-specific (mg/kg)
S	Solubility in water	Chemical-specific (mg/L)
K_d	Soil-water partition coefficient	$K_{oc}*f_{oc}$ (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 or n – Θ_w

*H' = Henry's law constant ÷ (universal gas constant × absolute temperature).

Table 4
Parameters Used to Derive the PEF

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

3.8 Recreational SSLs

The recreational SSLs for soil (Appendix D) were calculated using the chemical-specific parameter values and methodology described in NMED guidance (NMED 2017, 602273) and the exposure parameters presented in Table 1. As described in section 3.1, the most recent available values of chemical-specific toxicity criteria have been used for calculating the recreational SSLs. The recreational SSLs presented in the second column of the table in Appendix D are the lower (more protective) of the carcinogenic SSLs and the noncarcinogenic SSLs. Footnotes indicate whether the SSL exceeds the C_{sat} (for VOCs that are not solids at ambient soil temperature only) or a ceiling limit (100,000 mg/kg) when calculated SSLs are above 10% of the soil by mass, as described in Section 5.1 of the User's Guide for EPA's regional screening levels (https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide-june-2017#ceiling). The Excel workbook, which presents the exposure parameters, toxicity values, and physical and chemical information used to calculate the recreational SSLs, is provided on CD (Appendix C). This workbook also provides pathway-specific screening criteria, and the SSLs integrating exposure pathways for both carcinogenic and noncarcinogenic endpoints for each chemical.

4.0 REFERENCES

The following reference list includes documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ERID or ESHID. This information is also included in text citations. ERIDs were assigned by the Associate Directorate for ADEM's Records Processing Facility (IDs through 599999), and ESHIDs are assigned by the Environment, Safety, and Health Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and ADEM maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

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Appendix A

Basis of Exposure Parameters
Used to Calculate Recreational Soil Screening Levels

A-1.0 ADULT ON-SITE SOIL INGESTION RATE

In developing the exposure parameter value for incidental soil ingestion through recreational exposures, the conservative assumption was made that all adult soil ingestion occurs during the time the adult is outdoors. The outdoor time at the site is set at 1 h/d based on the total amount of time spent walking per day (90^{th} percentile) in the western U.S. (EPA 2011, 208374, Table 16-26, p. 16-75). The total time spent outdoors per day for the adult is set at 200 min (3.3 h/d), which is the total mean time outdoors as an adult for an individual with a 26-yr exposure duration beginning at age 6 yr (12 to less than 32 yr as an adult) (EPA 2011, 208374, Tables ES-1 and 16-1). The adult outdoor exposure time is calculated as a weighted average based on three exposure periods (11 to less than 16 yr, 16 to less than 21 yr, and 18 to less than 65 yr) for which information is recorded in the Exposure Factors Handbook (EPA 2011 208374, Tables ES-1 and 16-1). A total time outdoors of 200 min (3.3 h) is calculated as (4 yr/20 yr × 100 min/d) + (5 yr/20 yr × 102 min/d) + (11 yr/20 yr × 281 min/d). It is assumed soil ingestion is proportional to the time outdoors (not just time in physical activity). The recreational scenario soil ingestion rate for the adult is calculated as (100 mg/d) × (1 h/d on-site /3.3 h/d) = 30 mg/d of soil ingested during on-site recreational activities.

A-2.0 CHILD SOIL INGESTION RATE

In developing the exposure parameter for incidental soil ingestion through recreational exposures, the conservative assumption was made that all soil ingestion by the child occurs when the child is outdoors. The outdoor time at the site is set at 1 h/d based on the total amount of time spent walking per day (90^{th} percentile) in the western U.S. (EPA 2011, 208374, Table 16-26, p. 16-75). The time outdoors per day is set at 132 min (2.2 h/d), which is the total mean time outdoors for a 6- to less than 11-yr-old child (EPA 2011, 208374, Tables ES-1 and 16-1). The upper percentile value for total daily soil and dust ingestion for children of 200 mg/d was used to reflect conditions in this area of the country where vegetation is sparse, winds are prevalent, and incidental soil ingestion may occur to a greater extent than is generally the case. Therefore, the on-site soil ingestion for the child was set to (200 mg/d) × (1 h/d on-site/2.2 h/d) = 91 mg/d of soil ingested.

A-3.0 SURFACE AREA FOR SKIN EXPOSURE TO SOIL

The skin surface area to which soil may adhere for the adult recreational receptor (6032 cm^2) is the same as that used by the New Mexico Environment Department (NMED) to calculate soil screening levels (SSLs) for residential exposure (NMED 2017, 602273), which includes the head, hands, forearms, lower legs, and feet. For consistency, the skin surface area to which soil may adhere for the recreational SSL child was set to a value that assumes exposure to the same body parts for a child between 6 to less than 12 yr of age. The exposed skin surface area for this child receptor was calculated using the body-part-specific surface area fractions and total mean body surface area for relevant age groups in Tables 7-8, 7-10, and 7-11 of the Exposure Factors Handbook (EPA 2011, 208374). The percentage of skin surface area for different body parts for male and female children is provided for ages 6, 8, 10, and 12 yr in Table 7-8 (EPA 2011, 208374). These data were applied to total mean body surface area information for age groups 6 to less than 11 yr and 11 to less than 16 yr from Tables 7-10 and 7-11 (EPA 2011, 208374).

Values for the percentage of body part skin surface area, and total skin surface area, used to calculate exposed skin surface area for the child recreational SSL receptor are provided in Tables A-1 and A-2.

Table A-1
Percentage of Body Part Skin Surface Area

Body Parts	Percent of Total Skin Surface Area			
	Mean; Ages 6, 8, and 10 yr (male)	Mean; Ages 6, 8, and 10 yr (female)	Age 12 yr (male)	Age 12 yr (female)
Head	6.1	6.1	4.9	4.8
Lower arms	5.6	5.4	5.5	5.5
Hands	4.7	4.7	4.7	4.5
Legs	11.5	11.6	11.9	12.5
Feet	6.9	6.6	7.0	6.5
SUM	34.9%	34.4%	34.0%	33.8%

Table A-2
Total Skin Surface Area

Total Mean Body Surface Area (m^2)			
6 to <11 yr (male)	6 to <11 yr (female)	11 to <16 yr (male)	11 to <16 yr (female)
1.09	1.08	1.61	1.57

Male skin surface area (4079 cm^2) was calculated for a 6-yr child exposure duration by weighting ages 6, 8, and 10 yr by 5/6 and age 12 (conservatively assigned to age less than 12 yr) by 1/6:

$$[(34.9\% / 100) \times 5/6 \times 1.09\ m^2 + (34.0\% / 100) \times 1/6 \times 1.61\ m^2] \times 10{,}000\ cm^2/m^2$$

Female skin surface area (3980 cm^2) was calculated in an analogous manner. The average of male and female exposed skin surface area (4030 cm^2) was used to calculate the recreational SSLs.

A-4.0 REFERENCES

The following reference list includes documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ERID or ESHID. This information is also included in text citations. ERIDs were assigned by the Associate Directorate for Environmental Management's (ADEM's) Records Processing Facility (IDs through 599999), and ESHIDs are assigned by the Environment, Safety, and Health Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and ADEM maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

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Appendix B

Derivation of the Recreational Soil Screening Levels for Lead

Lead is a naturally occurring metal in the environment, but human uses such as leaded gasoline and lead-based paints have resulted in increased concentrations, particularly in urban areas. Industrial releases may also contribute to locally elevated environmental lead concentrations. Exposure to inorganic forms of lead is associated with health effects, including neurotoxicity, developmental delays, hypertension, impaired hearing acuity, impaired hemoglobin synthesis, and male reproductive impairment (https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0277_summary.pdf). Lead exposure is of particular concern for children whose physiology and behavior cause them to be more susceptible to the effects of lead in environmental media such as soil and dust (http://www.atsdr.cdc.gov/toxprofiles/tp13.pdf).

The U.S. Environmental Protection Agency (EPA) has not established toxicity criteria such as the reference dose and reference concentration for lead. Potential health risks related to childhood lead exposure are evaluated by modeling blood lead concentrations using the Integrated Exposure Uptake Biokinetic (IEUBK) model. The IEUBK model was used to develop the residential lead soil screening level (SSL) of 400 mg/kg cited in Section 2.3.3 of New Mexico Environment Department guidance (NMED 2017, 602273) and EPA's regional screening tables (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-june-2017). A target blood lead threshold of a 5% probability of a child having a blood lead level exceeding 10 μg/dL is generally used as the criterion to determine whether potential blood lead levels are of concern (EPA 1994, 059509). This threshold is associated with the 400 mg/kg standard. Site-related residential exposures contributing to the 400 mg/kg screening level include soil ingestion from the yard and indoor ingestion of house dust contaminated with soil. In addition to these site-related exposures, the 400 mg/kg screening level incorporates background levels of lead exposure from nonsite-related sources (e.g., ambient air, drinking water, and diet). For the calculation of the 400 mg/kg screening level, these background exposures were defined using national averages or typical values where suitable (EPA 1994, 059509).

The recreational lead SSL for a child was calculated using Version 1.1 Build 11 of the IEUBK model (https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals). This model can be used to derive soil criteria for exposure of children of various age ranges from birth through 7 yr of age. To compute the recreational SSL, Los Alamos–specific values were used for several model parameters, including the

- indoor dust lead concentration,
- time spent outdoors,
- lead concentration in drinking water, and
- age group.

When using all default values, Version 1.1 Build 11 of the IEUBK model produces an SSL of 418 mg/kg, which is approximately equivalent to the original value of 400 mg/kg calculated in 1994 using version 0.99d of the IEUBK model. The Version 1.1 Build 11 IEUBK model input values that were altered for the recreational scenario calculations are described below. All other IEUBK model inputs, including food lead concentrations and all media-specific ingestion rates, were left as default values.

The indoor dust lead concentration was defined based on the mean ambient soil lead level (12.7 mg/kg) for Los Alamos (LANL 1998, 059730). The default soil ingestion to indoor dust ingestion weighting factor of 0.45 was used. If this ratio is used, the lead SSL is relatively insensitive to changes in the indoor dust lead concentration. Doubling the value to 25 mg/kg has a negligible impact (approximately a 1% change) on the calculated SSL.

Time spent outdoors was defined as the recreational scenario outdoor exposure time (1 h/d) in the area of elevated soil lead concentrations. In principle, the daily time spent outdoors for the IEUBK model input should be lowered by the recreational exposure frequency fraction (200 d/yr per 365 d/yr) because the IEUBK model presumes daily exposure. However, the outdoor time parameter is used in the IEUBK model only in calculating the contribution of the ambient dust inhalation exposure pathway. This exposure pathway was determined to have a negligible impact on the SSL; varying the exposure time input value between 0.5 and 5 h/d did not affect the calculated SSL.

An estimated lead drinking water concentration of 0.5 µg/L (0.5 ppb) was used in IEUBK model calculation of the recreational SSL for lead. This estimate was derived from information in a “2010 Drinking Water Quality Report,” published by the Los Alamos Department of Public Utilities (Attachment B-1), which stated that 98.7% of home taps tested in 2008 had concentrations that were lower than the analytical detection limit of 0.5 ppb.

The age group selected for displaying the IEUBK output was related to the recreational exposure model, which specifies a child receptor between the ages of 6 to less than 12 yr. As noted above, the IEUBK model applies to children from birth up to an age of 7 yr. Therefore, an age group of 4 to 7 yr was selected in the IEUBK model. The recreational lead SSL for this age group calculated using the IEUBK model is 1110 mg/kg.

REFERENCES

The following reference list includes documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ERID or ESHID. This information is also included in text citations. ERIDs were assigned by the Associate Directorate for Environmental Management’s (ADEM’s) Records Processing Facility (IDs through 599999), and ESHIDs are assigned by the Environment, Safety, and Health Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory’s Electronic Document Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and ADEM maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

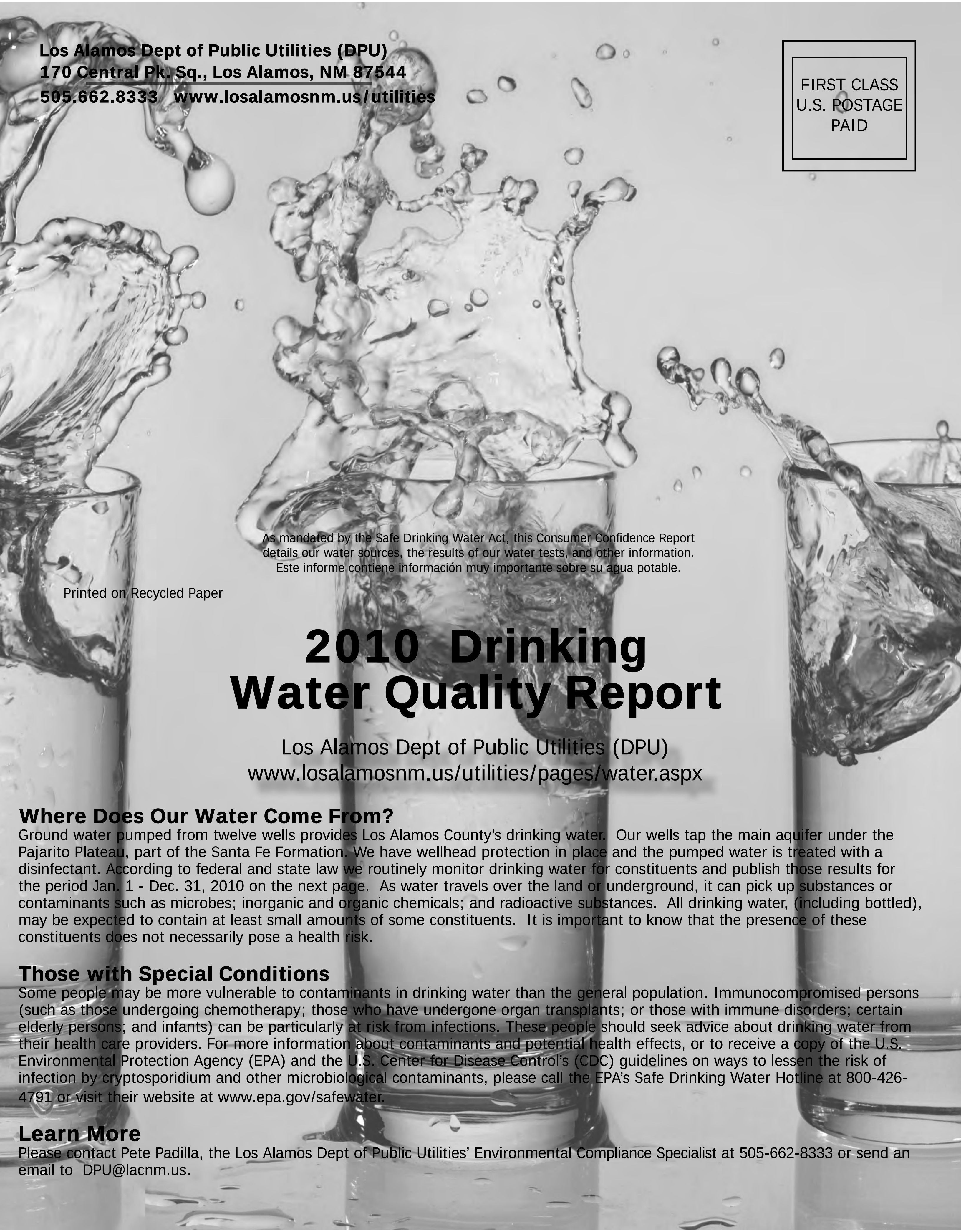
EPA (U.S. Environmental Protection Agency), July 14, 1994. “Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities,” OSWER Directive No. 9355.4-12, U.S. Environmental Protection Agency memorandum to Regional Administrators I-X from Elliot P. Laws (Assistant Administrator), Washington, D.C. (EPA 1994, 059509)

LANL (Los Alamos National Laboratory), September 22, 1998. “Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory,” Los Alamos National Laboratory document LA-UR-98-4847, Los Alamos, New Mexico. (LANL 1998, 059730)

NMED (New Mexico Environment Department), March 2017. “Risk Assessment Guidance for Site Investigations and Remediation, Volume 1, Soil Screening Guidance for Human Health Risk Assessments,” Hazardous Waste Bureau and Ground Water Quality Bureau, Santa Fe, New Mexico. (NMED 2017, 602273)

Attachment B-1

2010 Los Alamos County Drinking Water Quality Report



Los Alamos Dept of Public Utilities (DPU)
170 Central Pk. Sq., Los Alamos, NM 87544
505.662.8333 www.losalamosnm.us/utilities

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As mandated by the Safe Drinking Water Act, this Consumer Confidence Report details our water sources, the results of our water tests, and other information.
Este informe contiene información muy importante sobre su agua potable.

Printed on Recycled Paper

2010 Drinking Water Quality Report

Los Alamos Dept of Public Utilities (DPU)
www.losalamosnm.us/utilities/pages/water.aspx

Where Does Our Water Come From?

Ground water pumped from twelve wells provides Los Alamos County's drinking water. Our wells tap the main aquifer under the Pajarito Plateau, part of the Santa Fe Formation. We have wellhead protection in place and the pumped water is treated with a disinfectant. According to federal and state law we routinely monitor drinking water for constituents and publish those results for the period Jan. 1 - Dec. 31, 2010 on the next page. As water travels over the land or underground, it can pick up substances or contaminants such as microbes; inorganic and organic chemicals; and radioactive substances. All drinking water, (including bottled), may be expected to contain at least small amounts of some constituents. It is important to know that the presence of these constituents does not necessarily pose a health risk.

Those with Special Conditions

Some people may be more vulnerable to contaminants in drinking water than the general population. Immunocompromised persons (such as those undergoing chemotherapy; those who have undergone organ transplants; or those with immune disorders; certain elderly persons; and infants) can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. For more information about contaminants and potential health effects, or to receive a copy of the U.S. Environmental Protection Agency (EPA) and the U.S. Center for Disease Control's (CDC) guidelines on ways to lessen the risk of infection by cryptosporidium and other microbiological contaminants, please call the EPA's Safe Drinking Water Hotline at 800-426-4791 or visit their website at www.epa.gov/safewater.

Learn More

Please contact Pete Padilla, the Los Alamos Dept of Public Utilities' Environmental Compliance Specialist at 505-662-8333 or send an email to DPU@lacnm.us.

Consumer Confidence Report on Drinking Water Quality for 2010

Detected Contaminant (Unit Measurement)	Violation Y/N	Range of Levels Detected	System Average	Date Tested	MCLG	MCL	Likely Source of Contamination
Inorganic Compounds							
Arsenic (ppb)	N	Non-detect - 5.15ppb	1.03ppb	5/27/10 5/28/10 8/11/10	0	10ppb	Natural deposits
Chromium (ppb)	N	Non-detect - 6.7ppb	3.66ppb	2/17/10 5/27/10 5/28/10 9/11/10	100ppb	100ppb	Natural deposits
Fluoride (ppm)	N	0.315 - 0.673ppm	0.421ppm	5/27/10 5/28/10 8/11/10	4ppm	4ppm	Natural deposits
Nitrate & Nitrite (ppm)	N	0.32 - 0.51	0.433	5/5/10	10ppm	10ppm	Leaching septic tanks, sewage; natural deposits
Lead (residential taps) (ppb)	N	Non-detect - 14ppb	98.7% < detection limit of 5ppb	7/08	0	AL= 15ppb[1]	Corrosion of household plumbing
Copper (residential taps) (ppm)	N	Non-detect - 0.19ppm	96.7%<detection limit of 0.09 ppm	7/08	0	AL= 1.3ppm[1]	Corrosion of household plumbing
Hardness (as $CaCO_3$) (grains/gal)	N	1.64 - 5.34 grains/gal	3.18 grains/gal	5/18/10 5/19/10	-	-	Natural deposits
Disinfection By-Products							
Total Trihalomethanes (TTHMs)[2] (ppb)	N	0.6 - 0.9ppb	0.76ppb	5/18/10	0	80ppb	By-product of drinking water chlorination
Radionuclides							
Alpha emitters[3] (pCi/L)	N	-0.09 - 50.2Ci/L	8.18pCi/L	5/18/10 5/19/10	0	15pCi/L	Erosion of natural deposits
Beta/photon emitters (pCi/L)	N	0.719 - 28.4pCi/L	5.035pCi/L	5/18/10 5/19/10	0	50pCi/L	Decay of natural and man-made deposits
Microbiology							
Total Coliform (cfu per 100mL)[3]	N	Monthly Samples max. positive 0 of 29 (0%) min. positive 0 of 28 (0%)	Total positive samples 2010: 0 of 346	Monthly 2010	0	5%	Naturally present in the environment

Notes

[1]The Action Level (AL) for lead/copper is exceeded if 90 percent of homes tested have lead levels above 15 ppb and copper levels above 1.3 ppm. Note that 98.7% of home taps tested for lead in 2008 were lower than the detection limit of 0.5ppb. Samples are collected every three years with the next test in 2011. (Send email to DPU@lacnm.us if interested in participating in 2011 testing.) No lead/copper samples collected in 2008 exceeded the Action Level.

[2]On October 23, 2006 the NMED Drinking Water Bureau reduced the monitoring requirements for TTHM's to once per year due to the Los Alamos County running average of 30 µg/L Halo Acetic Acid (HAA5) and 40 µg/L TTHM under the 30/40 rule. The change was allowed because Los Alamos water is consistently well-below the threshhold values in this rule.

[3]In 2009 the NMED Drinking Water Bureau reduced funding for bacteriological samples to only 25 per month. Prior to this, up to 43 samples were collected in the system each month. The MCL for total coliforms is exceeded when coliform bacteria are present in 5% or more of the monthly samples.

Updates

On May 5, 2010 the New Mexico Environmental Dept./Drinking Water Bureau sampled for the U.S. Environmental Protection Agency water samples from the water system entry points as part of the Unregulated Contaminants Monitoring Rule (UCMR2). All results were Non-Detect (ND).

Beginning in January 2011, new regulations from the NMED Drinking Water Bureau mandate that the Los Alamos Dept. of Public Utilities be responsible for the collection of all Total Trihalomethanes (TTHMs) and Haloacetic Acids (HAA5s) samples from the water distribution system. Another new requirement for 2011 will be the colleciton of asbestos samples from areas in the distribution systems that contain Asbestos Cement Pipe (ACP) which occur in small sections within Los Alamos County.

Water Quality

We are pleased to report that once again, there were no violations of drinking water quality standards in 2010. Our water production and water distribution divisions provide water to approximately 7,000 customer meters in Los Alamos County, Bandelier National Monument and at Los Alamos National Laboratory. We're proud to provide Los Alamos with water that not only meets federal and state requirements; it beats them. Although certain low-level contaminants are detected through our continuous monitoring and testing of the water supply, the Environmental Protection Agency has determined that Los Alamos' water is safe. The Consumer Confidence Report (CCR) on the facing page provides the data and notes supporting this safe determination.

About Certain CCR Substances

Arsenic. While Los Alamos drinking water contains a low level of naturally occuring arsenic, it is less than the current Maximum Contaminant Level (MCL) of 10 ppb. The MCL standard balances the current understanding of arsenic's possible health effects against the costs of its removal from drinking water. The Environmental Protection Agency continues to research the health effects of very low levels of arsenic. At high concentrations, the mineral arsenic is known to cause cancer in humans, and is linked to other health effects such as skin damage and circulatory problems.

Chromium. In response to an elevated detection of chromium in a regional aquifer monitoring well during 2005, Los Alamos National Laboratory (LANL) and the DPU began monitoring Los Alamos' drinking water supply wells for both total and hexavalent [Cr(VI)] chromium. Hexavalent chromium was detected on Oct. 23, 2007 at safe levels in Otowi Well 1 for the first time, which is not in use for drinking water. Detected levels at 6.1 ppb are well below the EPA's drinking water standard of 100 ppb and New Mexico's established ground water standard of 50 ppb. Chromium is everywhere and can be found in three forms: metal ore, trivalent [Cr(III)], and hexavalent [Cr(VI)]. Trivalent chromium, a required nutrient, occurs naturally in fresh produce, meat, grains, and yeast. Relatively insoluble, it is the most prevalent form of chromium found in surface soils. Hexavalent chromium can sometimes be an indicator of human pollution. Hexavalent chromium is relatively soluble, can move through soil to ground water, and is considered more toxic than trivalent chromium.

How To Read the CCR's Headings & Measurement Units

- ppm = Parts per Million or Milligrams per Liter (mg/l). A ppm corresponds to a minute in two years or a penny in $10,000.
- ppb = Parts per Billion or Micrograms per Liter. A ppb corresponds to a minute in 2,000 years, or a penny in $10,000,000.
- pCi/L = Picocuries per Liter. Picocuries per liter is a measure of the radioactivity in water.
- MCLG = Maximum Contaminant Level Goal. The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.
- MCL = Maximum Contaminant Level. The "Maximum Allowed" is the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.
- Range of Levels Detected = The minimum to maximum test results observed in 2010.

Lead Safety

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. The lead levels in Los Alamos drinking water are not elevated and do not exceed EPA action levels. Lead in drinking water is primarily from material and components associated with service lines and home plumbing. The Los Alamos Dept. of Public Utilities is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. After water has been sitting in a pipe for several hours, the potential for lead exposure can be minimized by flushing the tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available at www.epa.gov/drink/info/lead/index.cfm.

About Other Substances

Cryptosporidium. This is a microbial pathogen found in surface water (rivers and streams) throughout the United States. When ingested, cryptosporidium can result in diarrhea, fever, and other gastrointestinal symptoms. Los Alamos water is ground water, not surface water. Hence it is pumped from wells and does not come from rivers. As expected, cryptosporidium has not been detected in our water supply.

Perchlorate. Very low, but positive, detections of perchlorate (1.5-2.0 ppb) were identified over the last few years in Otowi Well 1, which is not in use for drinking water. Although EPA has not set an MCL for perchlorate, it has established an official reference dose (RfD) of 0.0007 mg/kg/day of perchlorate ingested from all sources, including drinking water. The equivalent level would be 24.5 ppb if a person's total exposure to perchlorate were from drinking water alone. Perchlorate interferes with the production of thyroid hormones, which are required for normal pre- and postnatal development in humans, as well as normal body metabolism. See http://water.epa.gov/drink/contaminants/unregulated/perchlorate.cfm

About Organic Chemicals

Organic chemical contaminants, such as synthetic organic compounds (SOCs) and volatile organic compounds (VOCs) are by-products of industrial processes and petroleum production. Sources of contamination can come from gas stations, urban storm water run-off, and septic systems. Entry points into our drinking water supply were sampled by the New Mexico Environmental Dept./Drinking Water Bureau for SOCs and VOCs and all sample results were below detectable levels.

Special Water Quality Monitoring

Under the Unregulated Contaminant Monitoring Rule, the EPA collected water samples from the Los Alamos water system to test for contaminants that are currently not listed as regulated. Based in part on this sampling, EPA may decide to regulate one or more such contaminant candidates in the future to protect the public health. All sample results were below the reporting limit (none detected).

Source Water Assessment & Protection

We protect our drinking water from contamination based on well construction, hydrogeologic settings, and system operations and management. A Source Water Assessment & Protection (SWAP) analysis was performed in 2003 by the New Mexico Environment Department (NMED) to identify any possible sources of contamination. NMED ranked the susceptibility of our entire water system as "moderately high." To discuss findings please contact Pete Padilla, Environmental Compliance Specialist, (505) 662-8333.

Water Rights

Total water rights available to the Los Alamos townsite and White Rock, as determined by the Office of the New Mexico State Engineer, amount to 5,541.3 acre-feet per year. Los Alamos also has a contract with the U.S. Bureau of Reclamation for 1,200 more acre-feet of water per year from the San Juan/Chama transmountain diversion project. DPU is performing feasibility studies to utilize this water.

This additional source, coupled with conservation, will provide sufficient water to support future population growth and may help support the County Council's goal of diversifying the economy and bringing affordable housing to Los Alamos.

Water System Projects

DPU continued with capital improvements in 2010 that keep our water safe, enhance public safety and improve quality of life for all customers. System improvements were completed which replaced aging infrastructure and enhanced fire protection capacity as well.

2010 Diamond IV & V Water Line Renewal

Diamond Drive reconstruction Phases IV and V included significant water line improvements. As part of Diamond Phase IV, 2,300 feet of 16 inch ductile iron pipe was installed to replace two waterlines installed in the 1940s. In addition, 1600 feet of 8 inch PVC was installed to replace a 1940s 8 inch line. Phase V included the replacement of three waterlines that cross Diamond Drive. Each of the existing crossings were installed in the 1940s.

Pajarito Booster Tank 1

The 1.5 million gallon water tank located on Los Alamos National Laboratory property was built in 1965 and was due for re-coating, inside and out. To maintain uninterrupted water service to White Rock from an upstream water tank in the system. A bypass line was constructed to ensure adequate water for fire protection and drinking purposes. The project was completed protecting the tank for the next 25 years.

Gold Street Improvements

We replaced 425 feet of vintage 1940s cast iron pipe with PVC pipe. Natural gas work was already underway in the area, and the waterlines here had been prioritized for replacement due to previous line failures. DPU took the opportunity to dig once, and address two different utility issues. The efficiency not only keeps costs down but reduces disruption for citizens and motorists.

LA Reservoir

Years of negotiation and coordination with multiple state and federal agencies for the rehabilitation of the Los Alamos Reservoir finally came to fruition in 2010. Final approvals occurred, and a permit was issued for the project which was awarded to the contractor. Although the LA Reservoir water is nonpotable, its use for irrigation reduces the use of potable water for the same purpose. In this way the LA Reservoir project, once completed next year will help reduce costs and conserve ground water supply.

Los Alamos Reservoir, February 2011.

Utilities Board

As a public enterprise, the DPU reports to the Board of Public Utilities. The Board approves the DPU's rules regulations, policies, and standards which are designed to ensure the provision of safe, adequate, and proper utility services at reasonable rates. Composed of five county residents appointed by the County Council, our Utilities Board members are your local friends and neighbors. They are: D. Chris Ortega, Chair; Glenn Woodwell, Vice Chair; Thurman Talley; Paul Smith; and Timothy Neal.

Your Input is Welcome

The public is always welcome to join us at each month's Utility Board meeting held on the third Wednesday 5:30 p.m. at 170 Central Park Square. Please call or email to receive an agenda at 505-662-8333 or DPU@lacnm.us, or download your own copy at our website:

www.LosAlamosNM.us/gov/bcc/UtilitiesBoard.

Appendix C

Exposure Parameters, Toxicity Values, Physical and Chemical Information, and Soil Screening Level Calculations (on CD included with this document)

Appendix D

Recreational Soil Screening Levels for Chemicals

Chemical	Recreational SSL[a] (mg/kg)	Carcinogenic SSLs (mg/kg)	Noncarcinogenic SSLs (mg/kg)	C_{sat} SSL (mg/kg)
Acenaphthene	1.73E+04	No data[b]	1.7E+04	Not applicable
Acetaldehyde	9.64E+03	1.3E+04	9.6E+03	1.75E+05
Acetone[c]	5.50E+05[d]	No data	5.5E+05	1.77E+05
Acetophenone	6.19E+04	No data	6.2E+04	Not applicable
Acrolein	1.68E+01	No data	1.7E+01	3.72E+04
Acrylonitrile	7.21E+01	7.2E+01	1.5E+03	1.39E+04
Alachlor	4.44E+02	4.4E+02	3.3E+03	Not applicable
Aldrin	1.46E+00	1.5E+00	9.8E+00	Not applicable
Aluminum	6.19E+05[d]	No data	6.2E+05	Not applicable
Aniline	2.30E+03	4.4E+03	2.3E+03	Not applicable
Anthracene	8.63E+04	No data	8.6E+04	Not applicable
Antimony	2.48E+02	No data	2.5E+02	Not applicable
Arsenic	4.29E+01	4.3E+01	8.8E+01	Not applicable
Atrazine	1.08E+02	1.1E+02	1.1E+04	Not applicable
Barium	1.24E+05[d]	No data	1.2E+05	Not applicable
Benzene	4.29E+02	4.3E+02	1.8E+03	7.49E+02
Benzidine (M)[e]	4.43E-02	4.4E-02	9.8E+02	Not applicable
Benzo(a)anthracene (M)	8.88E+01	8.9E+01	No data	Not applicable
Benzo(a)pyrene (M)	8.88E+00	8.9E+00	8.6E+01	Not applicable
Benzo(b)fluoranthene (M)	8.88E+01	8.9E+01	No data	Not applicable
Benzo(k)fluoranthene (M)	8.88E+02	8.9E+02	No data	Not applicable
Benzoic acid	1.31E+06[d]	No data	1.3E+06	Not applicable
Benzyl alcohol	3.28E+04	No data	3.3E+04	Not applicable
Beryllium	1.24E+03	3.2E+06	1.2E+03	Not applicable
a-BHC (HCH)	3.94E+00	3.9E+00	2.6E+03	Not applicable
b-BHC (HCH)	1.38E+01	1.4E+01	No data	Not applicable
g-BHC	3.26E+01	3.3E+01	1.4E+02	Not applicable
1,1-Biphenyl[f]	2.44E+03	6.3E+03	2.4E+03	5.46E+01
Bis(2-chloroethyl) ether	3.86E+01	3.9E+01	No data	3.81E+03
Bis(2-chloroisopropyl) ether	7.25E+02	7.2E+02	2.5E+04	Not applicable
Bis(2-ethylhexyl) phthalate	1.77E+03	1.8E+03	6.6E+03	Not applicable
Bis(chloromethyl) ether	6.28E-02	6.3E-02	No data	4.58E+03
Boron	1.24E+05[d]	No data	1.2E+05	Not applicable
Bromobenzene[c]	4.26E+03	No data	4.3E+03	2.39E+02
Bromodichloromethane	1.94E+02	1.9E+02	1.2E+04	7.00E+02
Bromomethane	4.21E+02	No data	4.2E+02	3.45E+03
1,3-Butadiene	1.09E+01	1.1E+01	8.9E+01	4.23E+02
2-Butanone (Methyl ethyl ketone, MEK)[c]	3.53E+05[d]	No data	3.5E+05	4.02E+04
Butyl benzyl phthalate	1.31E+04	1.3E+04	6.6E+04	Not applicable

Chemical	Recreational SSL[a] (mg/kg)	Carcinogenic SSLs (mg/kg)	Noncarcinogenic SSLs (mg/kg)	C_{sat} SSL (mg/kg)
tert-Butyl methyl ether (MTBE)[c]	1.81E+04	1.8E+04	1.5E+06	9.86E+03
n-Butylbenzene	3.10E+04	No data	3.1E+04	Not applicable
sec-Butylbenzene	6.19E+04	No data	6.2E+04	Not applicable
tert-Butylbenzene	6.19E+04	No data	6.2E+04	Not applicable
Cadmium	4.57E+02	4.3E+06	4.6E+02	Not applicable
Carbofuran	1.64E+03	No data	1.6E+03	Not applicable
Carbon disulfide[c]	3.40E+04	No data	3.4E+04	5.89E+02
Carbon tetrachloride	2.84E+02	2.8E+02	2.0E+03	2.91E+02
Chlordane	1.02E+02	1.0E+02	2.3E+02	Not applicable
2-Chloroacetophenone	8.69E+06[d]	No data	8.7E+06	Not applicable
p-Chloroaniline	1.24E+02	1.2E+02	1.3E+03	Not applicable
2-Chloro-1,3-butadiene	6.78E+00	6.8E+00	1.3E+03	4.59E+02
1-Chloro-1,1-difluoroethane[c]	4.24E+06[d]	No data	4.2E+06	7.17E+02
Chlorobenzene[c]	7.55E+03	No data	7.5E+03	2.68E+02
1-Chlorobutane	2.48E+04	No data	2.5E+04	Not applicable
p-Chloro-m-cresol	3.28E+04	No data	3.3E+04	Not applicable
Chlorodifluoromethane[c]	3.98E+06[d]	No data	4.0E+06	1.13E+03
Chloroethane (ethyl chloride)[c]	1.19E+06[d]	No data	1.2E+06	1.73E+03
Chloroform	2.04E+02	2.0E+02	4.7E+03	1.89E+03
Chloromethane	1.20E+03	1.2E+03	1.0E+04	1.25E+03
b-Chloronaphthalene	4.95E+04	No data	5.0E+04	Not applicable
o-Chloronitrobenzene	8.28E+01	8.3E+01	9.8E+02	Not applicable
p-Chloronitrobenzene	2.30E+02	4.1E+02	2.3E+02	Not applicable
2-Chlorophenol	3.10E+03	No data	3.1E+03	Not applicable
2-Chloropropane[c]	1.11E+04	No data	1.1E+04	9.37E+02
o-Chlorotoluene	1.24E+04	No data	1.2E+04	Not applicable
Chromium III	9.29E+05[d]	No data	9.3E+05	Not applicable
Chromium VI (M)	4.02E+01	4.0E+01	1.9E+03	Not applicable
Chromium (Total) (M)	2.81E+02	2.8E+02	6.7E+05	Not applicable
Chrysene (M)	8.88E+03	8.9E+03	No data	Not applicable
Cobalt	1.86E+02	8.7E+05	1.9E+02	Not applicable
Copper	2.48E+04	No data	2.5E+04	Not applicable
Cresol-m	1.64E+04	No data	1.6E+04	Not applicable
Cresol-o	1.64E+04	No data	1.6E+04	Not applicable
Cresol-p	3.28E+04	No data	3.3E+04	Not applicable
Crotonaldehyde	2.67E+01	2.7E+01	6.2E+02	Not applicable
Cumene (isopropylbenzene)[c]	4.21E+04	No data	4.2E+04	7.83E+01
Cyanide	2.24E+02	No data	2.2E+02	1.78E+05
Cyanogen	6.19E+02	No data	6.2E+02	Not applicable

Chemical	Recreational SSL[a] (mg/kg)	Carcinogenic SSLs (mg/kg)	Noncarcinogenic SSLs (mg/kg)	C_{sat} SSL (mg/kg)
Cyanogen bromide	5.57E+04	No data	5.6E+04	Not applicable
Cyanogen chloride	3.10E+04	No data	3.1E+04	Not applicable
DDD	1.04E+02	1.0E+02	No data	Not applicable
DDE	7.31E+01	7.3E+01	No data	Not applicable
DDT	1.14E+02	1.1E+02	2.4E+02	Not applicable
Dibenz(a,h)anthracene (M)	8.88E+00	8.9E+00	No data	Not applicable
Dibenzofuran	4.89E+02	No data	4.9E+02	Not applicable
1,2-Dibromo-3-chloropropane (M)	1.27E+01	1.3E+01	6.6E+01	Not applicable
Dibromochloromethane	2.96E+02	3.0E+02	6.6E+03	Not applicable
1,2-Dibromoethane	1.42E+01	1.4E+01	3.0E+03	9.22E+02
1,4-Dichloro-2-butene	4.46E+00	4.5E+00	No data	2.17E+02
1,2-Dichlorobenzene[c]	3.81E+04	No data	3.8E+04	6.05E+01
1,3-Dichlorobenzene[c]	3.60E+04	No data	3.6E+04	9.35E+01
1,4-Dichlorobenzene[c]	1.14E+03	1.1E+03	3.9E+04	6.08E+01
3,3-Dichlorobenzidine	5.52E+01	5.5E+01	No data	Not applicable
Dichlorodifluoromethane[c]	6.75E+03	No data	6.7E+03	5.14E+02
1,1-Dichloroethane[c]	2.39E+03	2.4E+03	1.2E+05	1.25E+03
1,2-Dichloroethane	2.19E+02	2.2E+02	1.5E+03	1.21E+03
cis-1,2-Dichloroethene	1.24E+03	No data	1.2E+03	Not applicable
trans-1,2-Dichloroethene[c]	6.60E+03	No data	6.6E+03	8.81E+02
1,1-Dichloroethene[c]	1.19E+04	No data	1.2E+04	8.28E+02
2,4-Dichlorophenol	9.85E+02	No data	9.8E+02	Not applicable
1,2-Dichloropropane	1.78E+02	1.8E+02	1.1E+03	7.77E+02
1,3-Dichloropropene	4.03E+02	4.0E+02	4.4E+03	8.34E+02
Dicyclopentadiene	6.69E+01	No data	6.7E+01	1.42E+02
Dieldrin	1.55E+00	1.6E+00	1.6E+01	Not applicable
Diethyl phthalate	2.63E+05[d]	No data	2.6E+05	Not applicable
Di-n-butyl phthalate (Dibutyl phthalate)	3.28E+04	No data	3.3E+04	Not applicable
2,4-Dimethylphenol	6.57E+03	No data	6.6E+03	Not applicable
Dimethyl phthalate	3.28E+05[d]	No data	3.3E+05	Not applicable
Di-n-octyl phthalate	3.28E+03	No data	3.3E+03	Not applicable
4,6-Dinitro-o-cresol	2.63E+01	No data	2.6E+01	Not applicable
2,4-Dinitrophenol	6.57E+02	No data	6.6E+02	Not applicable
2,4-Dinitrotoluene	7.93E+01	7.9E+01	6.5E+02	Not applicable
2,6-Dinitrotoluene	1.67E+01	1.7E+01	9.9E+01	Not applicable
2,4/2,6-Dinitrotoluene Mixture	5.52E+01	5.5E+01	3.0E+02	Not applicable
2-Amino-4,6-dinitrotoluene	1.18E+03	No data	1.2E+03	Not applicable
4-Amino-2,6-dinitrotoluene	1.15E+03	No data	1.1E+03	Not applicable
1,4-Dioxane	2.48E+02	2.5E+02	9.8E+03	Not applicable

Chemical	Recreational SSL[a] (mg/kg)	Carcinogenic SSLs (mg/kg)	Noncarcinogenic SSLs (mg/kg)	C_{sat} SSL (mg/kg)
1,2-Diphenylhydrazine	3.11E+01	3.1E+01	No data	Not applicable
Endosulfan	1.97E+03	No data	2.0E+03	Not applicable
Endrin	9.85E+01	No data	9.8E+01	Not applicable
Epichlorohydrin	1.22E+03	4.6E+03	1.2E+03	1.24E+04
Ethyl acetate[c]	6.42E+04	No data	6.4E+04	1.46E+04
Ethyl acrylate	1.06E+03	1.1E+03	2.0E+03	Not applicable
Ethyl chloride[c]	7.37E+05[d]	No data	7.4E+05	1.73E+03
Ethyl ether	1.24E+05[d]	No data	1.2E+05	Not applicable
Ethyl methacrylate[c]	4.22E+04	No data	4.2E+04	1.09E+03
Ethylbenzene[c]	1.93E+03	1.9E+03	5.2E+04	1.49E+02
Ethylene oxide (M)	3.91E+00	3.9E+00	2.5E+04	1.79E+05
Fluoranthene	1.15E+04	No data	1.2E+04	Not applicable
Fluorene	1.15E+04	No data	1.2E+04	Not applicable
Fluoride	3.72E+04	No data	3.7E+04	Not applicable
Furan	4.89E+02	No data	4.9E+02	Not applicable
Glyphosate	3.28E+04	No data	3.3E+04	Not applicable
Heptachlor	5.52E+00	5.5E+00	1.6E+02	Not applicable
Heptachlor epoxide	5.58E+00	5.6E+00	8.1E+00	Not applicable
Hexachlorobenzene	1.55E+01	1.6E+01	2.6E+02	Not applicable
Hexachloro-1,3-butadiene	3.19E+02	3.2E+02	3.3E+02	Not applicable
Hexachlorocyclopentadiene	1.97E+03	No data	2.0E+03	Not applicable
Hexachloroethane	2.30E+02	6.2E+02	2.3E+02	Not applicable
n-Hexane[c]	1.58E+04	No data	1.6E+04	8.30E+01
2-Hexanone	2.87E+03	No data	2.9E+03	3.38E+03
HMX	2.94E+04	No data	2.9E+04	Not applicable
Hydrazine anhydride	8.28E+00	8.3E+00	8.7E+06	Not applicable
Hydrogen cyanide	2.15E+02	No data	2.1E+02	1.78E+05
Indeno(1,2,3-c,d)pyrene (M)	8.88E+01	8.9E+01	No data	Not applicable
Iron	4.34E+05[d]	No data	4.3E+05	Not applicable
Isobutanol (Isobutyl alcohol)	9.85E+04	No data	9.8E+04	Not applicable
Isophorone	2.62E+04	2.6E+04	6.6E+04	Not applicable
Lead	1.11E+03[g]	No data	No data	Not applicable
Lead (tetraethyl-)	3.28E-02	No data	3.3E-02	Not applicable
Lithium	1.24E+03	No data	1.2E+03	Not applicable
Maleic hydrazide	1.64E+05[d]	No data	1.6E+05	Not applicable
Manganese	1.48E+04	No data	1.5E+04	Not applicable
Mercury (elemental)[c]	9.22E+02	No data	9.2E+02	3.13E+00
Mercury (methyl)	6.19E+01	No data	6.2E+01	Not applicable
Mercuric Chloride (Mercury Salts)	1.86E+02	No data	1.9E+02	Not applicable

Chemical	Recreational SSL[a] (mg/kg)	Carcinogenic SSLs (mg/kg)	Noncarcinogenic SSLs (mg/kg)	C_{sat} SSL (mg/kg)
Methacrylonitrile	6.17E+01	No data	6.2E+01	4.93E+03
Methomyl	8.21E+03	No data	8.2E+03	Not applicable
Methoxychlor	1.64E+03	No data	1.6E+03	Not applicable
Methyl acetate	6.19E+05[d]	No data	6.2E+05	Not applicable
Methyl acrylate	8.58E+03	No data	8.6E+03	9.04E+03
Methyl isobutyl ketone[c]	4.88E+04	No data	4.9E+04	3.66E+03
Methyl methacrylate[c]	3.09E+05[d]	No data	3.1E+05	2.83E+03
Methyl styrene (alpha)	4.34E+04	No data	4.3E+04	Not applicable
Methyl styrene (mixture)[c]	3.24E+03	No data	3.2E+03	1.12E+02
Methylcyclohexane[c]	2.13E+05[d]	No data	2.1E+05	3.53E+01
Methylene bromide (Dibromomethane)	1.74E+03	No data	1.7E+03	2.50E+03
Methylene chloride (M)[c]	3.61E+03	9.7E+03	3.6E+03	2.87E+03
1-Methylnaphthalene	7.43E+02	7.4E+02	2.0E+04	Not applicable
2-Methylnaphthalene	1.15E+03	No data	1.2E+03	Not applicable
Molybdenum	3.10E+03	No data	3.1E+03	Not applicable
Naphthalene[f]	1.93E+03	1.9E+03	3.2E+03	7.74E+01
Nickel (soluble salts)	1.24E+04	3.0E+07	1.2E+04	Not applicable
Nitrate	9.91E+05[d]	No data	9.9E+05	Not applicable
Nitrite	6.19E+04	No data	6.2E+04	Not applicable
2-Nitroaniline	3.28E+03	No data	3.3E+03	Not applicable
4-Nitroaniline	1.24E+03	1.2E+03	1.3E+03	Not applicable
Nitrobenzene[c]	1.19E+03	2.3E+03	1.2E+03	1.07E+03
Nitroglycerin	3.28E+01	1.5E+03	3.3E+01	Not applicable
N-Nitrosodiethylamine (M)	6.79E-02	6.8E-02	No data	Not applicable
N-Nitrosodimethylamine (M)	2.00E-01	2.0E-01	2.6E+00	Not applicable
N-Nitrosodi-n-butylamine	4.46E+00	4.5E+00	No data	1.96E+03
N-Nitrosodiphenylamine	5.07E+03	5.1E+03	No data	Not applicable
N-Nitrosopyrrolidine	1.18E+01	1.2E+01	No data	Not applicable
m-Nitrotoluene	3.28E+01	No data	3.3E+01	Not applicable
o-Nitrotoluene	2.31E+02	2.3E+02	5.6E+02	Not applicable
p-Nitrotoluene	1.31E+03	1.6E+03	1.3E+03	Not applicable
Pentachlorobenzene	2.63E+02	No data	2.6E+02	Not applicable
Pentachlorophenol	3.52E+01	3.5E+01	9.6E+02	Not applicable
Pentaerythritol tetranitrate (PETN)	6.57E+02	6.2E+03	6.6E+02	Not applicable
Perchlorate	4.34E+02	No data	4.3E+02	Not applicable
Perfluorinate chemicals (PFCs)				
Perfluorohexane sulfonic acid (PFHxS)	0.00E+00	No data	No data	Not applicable
Perfluorooctane sulfonate (PFO, PFOS)	0.00E+00	No data	No data	Not applicable
Perfluorooctanoic acid (PFOA)	0.00E+00	No data	No data	Not applicable

Chemical	Recreational SSL[a] (mg/kg)	Carcinogenic SSLs (mg/kg)	Noncarcinogenic SSLs (mg/kg)	C_{sat} SSL (mg/kg)
Phenanthrene	8.63E+03	No data	8.6E+03	Not applicable
Phenol	9.85E+04	No data	9.8E+04	Not applicable
Polychlorinated biphenyls				
Aroclor-1016	1.93E+01	2.9E+02	1.9E+01	Not applicable
Aroclor-1221	9.94E+00	9.9E+00	No data	1.85E+01
Aroclor-1232	9.98E+00	1.0E+01	No data	1.85E+01
Aroclor-1242	1.03E+01	1.0E+01	No data	Not applicable
Aroclor-1248	1.03E+01	1.0E+01	No data	Not applicable
Aroclor-1254	5.53E+00	1.0E+01	5.5E+00	Not applicable
Aroclor-1260	1.03E+01	1.0E+01	No data	Not applicable
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 170)	1.59E+00	1.6E+00	1.9E+00	Not applicable
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 180)	1.59E+01	1.6E+01	1.9E+01	Not applicable
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB 189)	5.29E+00	5.3E+00	6.4E+00	Not applicable
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB 167)	5.29E+00	5.3E+00	6.4E+00	Not applicable
2,3,3',4,4',5'-Hexachlorobiphenyl (PCB 157)	5.29E+00	5.3E+00	6.4E+00	Not applicable
2,3,3',4,4',5-Hexachlorobiphenyl (PCB 156)	5.29E+00	5.3E+00	6.4E+00	Not applicable
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB 169)	5.29E-03	5.3E-03	6.4E-03	Not applicable
2',3,4,4',5-Pentachlorobiphenyl (PCB 123)	5.29E+00	5.3E+00	6.4E+00	Not applicable
2',3',4,4',5-Pentachlorobiphenyl (PCB 118)	5.29E+00	5.3E+00	6.4E+00	Not applicable
2',3,3',4,4'-Pentachlorobiphenyl (PCB 105)	5.29E+00	5.3E+00	6.4E+00	Not applicable
2,3,4,4',5-Pentachlorobiphenyl (PCB 114)	5.29E+00	5.3E+00	6.4E+00	Not applicable
3,3',4,4',5-Pentachlorobiphenyl (PCB 126)	1.59E-03	1.6E-03	1.9E-03	Not applicable
3,3',4,4'-Tetrachlorobiphenyl (PCB 77)	1.59E+00	1.6E+00	1.9E+00	Not applicable
3,4,4',5-Tetrachlorobiphenyl (PCB 81)	5.29E-01	5.3E-01	6.4E-01	Not applicable
n-Propylbenzene[c]	5.33E+04	No data	5.3E+04	7.53E+01
Propylene oxide	2.06E+02	2.1E+02	3.5E+04	1.07E+05
Pyrene	8.63E+03	No data	8.6E+03	Not applicable
RDX	3.99E+02	4.0E+02	1.6E+03	Not applicable
Selenium	3.10E+03	No data	3.1E+03	Not applicable
Silver	3.10E+03	No data	3.1E+03	Not applicable

Chemical	Recreational SSL[a] (mg/kg)	Carcinogenic SSLs (mg/kg)	Noncarcinogenic SSLs (mg/kg)	C_{sat} SSL (mg/kg)
Simazine	2.07E+02	2.1E+02	1.6E+03	Not applicable
Strontium	3.72E+05[d]	No data	3.7E+05	Not applicable
Styrene[c]	1.00E+05[d]	No data	1.0E+05	2.65E+02
Sulfolane	3.28E+02	No data	3.3E+02	Not applicable
2,3,7,8-TCDD	2.97E-04	3.0E-04	3.4E-04	Not applicable
2,3,7,8-TCDF	2.97E-03	3.0E-03	No data	Not applicable
1,2,4,5-Tetrachlorobenzene	9.85E+01	No data	9.8E+01	Not applicable
1,1,1,2-Tetrachloroethane[c]	7.48E+02	7.5E+02	1.9E+04	3.36E+02
1,1,2,2-Tetrachloroethane	1.56E+02	1.6E+02	1.2E+04	8.97E+02
Tetrachloroethene[c]	2.24E+03	9.1E+03	2.2E+03	8.19E+01
Tetryl (Trinitrophenylmethylnitramine)	1.23E+03	No data	1.2E+03	Not applicable
Thallium	6.19E+00	No data	6.2E+00	Not applicable
Toluene[c]	4.76E+04	No data	4.8E+04	2.92E+02
Toxaphene	2.26E+01	2.3E+01	No data	Not applicable
Tribromomethane (Bromoform)	3.15E+03	3.1E+03	6.6E+03	Not applicable
1,1,2-Trichloro-1,2,2-trifluoroethane[c]	3.29E+05[d]	No data	3.3E+05	4.96E+02
1,2,4-Trichlorobenzene	1.75E+03	1.7E+03	2.3E+03	Not applicable
1,1,1-Trichloroethane[c]	4.10E+05[d]	No data	4.1E+05	4.12E+02
1,1,2-Trichloroethane	9.81E+01	4.4E+02	9.8E+01	2.95E+02
Trichloroethylene (M)	1.57E+02	2.5E+02	1.6E+02	3.97E+02
Trichlorofluoromethane[c]	3.96E+04	No data	4.0E+04	7.59E+02
2,4,5-Trichlorophenol	3.28E+04	No data	3.3E+04	Not applicable
2,4,6-Trichlorophenol	3.28E+02	2.3E+03	3.3E+02	Not applicable
1,1,2-Trichloropropane	3.10E+03	No data	3.1E+03	Not applicable
1,2,3-Trichloropropane (M)	6.70E-01	6.7E-01	2.5E+02	6.11E+02
1,2,3-Trichloropropene	4.73E+01	No data	4.7E+01	1.43E+02
Triethylamine	7.47E+03	No data	7.5E+03	1.72E+04
1,2,3-Trimethylbenzene[c]	5.17E+03	No data	5.2E+03	8.53E+01
1,2,4-Trimethylbenzene[c]	5.01E+03	No data	5.0E+03	6.40E+01
1,3,5-Trimethylbenzene[c]	4.83E+03	No data	4.8E+03	5.38E+01
1,3,5-Trinitrobenzene	1.59E+04	No data	1.6E+04	Not applicable
2,4,6-Trinitrotoluene	2.41E+02	1.3E+03	2.4E+02	Not applicable
Uranium (soluble salts)	1.86E+03	No data	1.9E+03	Not applicable
Vanadium	3.10E+03	No data	3.1E+03	Not applicable
Vinyl acetate[c]	8.79E+04	No data	8.8E+04	3.68E+03
Vinyl bromide	1.05E+02	1.1E+02	3.7E+02	1.34E+03
Vinyl chloride (M)	2.55E+01	2.5E+01	1.5E+03	2.95E+03
m-Xylene[c]	2.49E+04	No data	2.5E+04	1.24E+02
o-Xylene[c]	2.60E+04	No data	2.6E+04	8.18E+01

Chemical	Recreational SSL[a] (mg/kg)	Carcinogenic SSLs (mg/kg)	Noncarcinogenic SSLs (mg/kg)	C_{sat} SSL (mg/kg)
p-Xylene[c]	2.56E+04	No data	2.6E+04	1.24E+02
Xylenes[c]	2.78E+04	No data	2.8E+04	8.18E+01
Zinc	1.86E+05[d]	No data	1.9E+05	Not applicable

Note: Not applicable indicates this chemical is not defined as volatile, or if volatile that no inhalation toxicity criteria are available. See section 3.3.1 for additional information.

[a] The recreational soil screening level (SSL) 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, if appropriate.

[b] "No data" indicates that oral and/or inhalation toxicity criteria for the endpoint are not available.

[c] This chemical is defined as a volatile organic compound (VOC), but the calculated SSL exceeds the soil saturation limit (C_{sat}) value, above which this chemical may occur as a nonaqueous phase liquid in soil. The volatilization factor model used to calculate the inhalation pathway SSL is unreliable under this condition. The SSLs presented include risks calculated for the inhalation pathway. The C_{sat} value is provided in the last column. See section 3.3.1 for additional information.

[d] The SSL exceeds the ceiling value of 100,000 mg/kg. The values presented are the calculated SSLs.

[e] (M) indicates the chemical is classified as a mutagen; SSL values for the carcinogenic endpoint are calculated with an adjustment to account for increased sensitivity to mutagenic effects from childhood exposures. See section 3.3.4 for additional information.

[f] This chemical is defined as a VOC, but the calculated SSL exceeds the C_{sat} value, and the chemical is expected to occur as a solid at ambient soil temperature. The SSLs values presented include risk calculated for the inhalation pathway. However, an SSL that does not include the inhalation exposure pathway may be appropriate for this chemical. See section 3.3.1 for additional information.

[g] The SSL for lead is derived using the U.S. Environmental Protection Agency's Integrated Exposure Uptake Biokinetic model (https://www.epa.gov/superfund/lead-superfund-sites-software-and-users-manuals). See Appendix B for additional information.

REFERENCE

The following reference list includes documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ERID or ESHID. This information is also included in text citations. ERIDs were assigned by the Associate Directorate for Environmental Management's (ADEM's) Records Processing Facility (IDs through 599999), and ESHIDs are assigned by the Environment, Safety, and Health Directorate (IDs 600000 and above). IDs are used to locate documents in the Laboratory's Electronic Document Management System and in the Master Reference Set. The NMED Hazardous Waste Bureau and ADEM maintain copies of the Master Reference Set. The set ensures that NMED has the references to review documents. The set is updated when new references are cited in documents.

NMED (New Mexico Environment Department), March 2017. "Risk Assessment Guidance for Site Investigations and Remediation, Volume I, Soil Screening Guidance for Human Health Risk Assessments," Hazardous Waste Bureau and Ground Water Quality Bureau Voluntary Remediation Program, Santa Fe, New Mexico. (NMED 2017, 602273)