FINAL
HUMAN HEALTH RISK ASSESSMENT FOR THE SOLAR EVAPORATION PONDS

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site

Golden, Colorado

Environmental Restoration
Kaiser-Hill Company, L L C
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ACRONYMS AND ABBREVIATIONS

AI	adequate intake
AL	action level
ALF	Action Levels and Standards Framework for Surface Water, Ground Water, and Soil
AOC	Area of Concern
ASD	Analytical Services Division
AUF	area use factor
AWF	area weighting factor
BZ	Buffer Zone
CAS	Chemical Abstract Services
CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^2	square centimeter
COC	contaminant of concern
CRA	Comprehensive Risk Assessment
DAF	dermal absorption factor
DOE	U S Department of Energy
DQA	Data Quality Assessment
DQO	Data Quality Objective
EPA	U S Environmental Protection Agency
ER	Environmental Restoration
ET	exposure time
ev/d	events per day
EU	exposure unit
GIS	Geographic Information System
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	hazard index
HQ	hazard quotient
hr/day	hours per day
IA	Industrial Area
IASAP	Industrial Area Sampling and Analysis Plan
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IRIS	Integrated Risk Information System
ITS	Interceptor Trench System
kg	kilograms
kg/m^3	kilograms per cubic meter
K-H	Kaiser-Hill Company, L L C
LCS	laboratory control sample
µg/kg	micrograms per kilogram
$\mu g/m^3$	micrograms per cubic meter

m^3/hr	cubic meters per hour
m^3/kg	cubic meters per kilogram
MARSSIM	Multi-Agency Radiological Survey and Site Manual
MDA	minimum detectable activity
mg	milligram
mg/cm^2	milligrams per square centimeter
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
ML	mass loading
MS	matrix spike
MSD	matrix spike duplicate
NA	not applicable
NCEA	National Center for Environmental Assessment
ND	not detected
NPWL	New Process Waste Lines
NRC	Nuclear Regulatory Commission
OPWL	Original Process Waste Lines
OU	Operable Unit
PAC	Potential Area of Concern
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCB	polychlorinated biphenyl
pCi	picocurie
pCi/g	picocuries per gram
PCOC	potential contaminant of concern
ppb	parts per billion
ppm	parts per million
PRG	preliminary remediation goal
QA	quality assurance
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RDA	recommended daily allowance
RDI	recommended daily intake
RfC	reference concentration
RFCA	Rocky Flats Cleanup Agreement
RfD	reference dose
RFETS (or Site)	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
RIN	report identification number
RME	reasonable maximum exposure
RPD	relative percent difference
RSAL	radionuclide soil action level
SEP	Solar Evaporation Ponds

SF	slope factor
SOP	standard operating procedure
SVOC	semivolatile organic compound
SWD	Soil Water Database
TCLP	Toxicity Characteristic Leaching Procedure
UCL	upper confidence limit
UL	upper limit
V&V	verification and validation
VOC	volatile organic compound
WRW	wildlife refuge worker
yr	year

1.0 INTRODUCTION AND PURPOSE

This Human Health Risk Assessment (HHRA) was performed for Individual Hazardous Substance Site (IHSS) 101, the Solar Evaporation Ponds (SEP), effluent pipe, a portion of IHSS 121, the Original Process Waste Lines (OPWL) Resource Conservation and Recovery Act (RCRA) Units 21 and 48, and Potential Area of Concern (PAC) 900-1310 (the Interceptor Trench System [ITS] water spill) at the Rocky Flats Environmental Technology Site (RFETS)[1] This assessment quantifies human health risk and evaluates any appropriate and necessary remedial actions or implementation of other risk management measures to ensure protection of human receptors following site closure The risk assessment was conducted in accordance with the anticipated future land use as a wildlife refuge Adverse health risks to wildlife refuge workers (WRWs) resulting from potential exposures to chemicals and radionuclides at or released from source term areas within the SEP Area of Concern (AOC) are quantified and evaluated Health risks are estimated for reasonable maximum exposure (RME) conditions as defined by U S Environmental Protection Agency (EPA) guidance (EPA 1989, 1992a)

Two risk assessments have previously been prepared for the SEP The first was performed for the Interim Measure/Interim Remedial Action (IM/IRA) document (DOE 1995), which was never approved by the regulatory agencies In response to deficiencies in the IM/IRA risk assessment, Environmental Restoration (ER) staff completed a draft of a second risk assessment in late 1995 The second risk assessment was prepared in close consultation with Colorado Department of Public Health and Environment (CDPHE) but was never finalized In addition, there have been several significant changes in anticipated land use since 1995 The changes in land use impact all phases of the risk assessment process, including receptors, exposure scenarios, exposure factors, preliminary remediation goals (PRGs), and the contaminant of concern (COC) selection process The toxicity factors used to calculate risks have also been updated since 1995

The current risk assessment incorporates data used in earlier risk assessments, and all recent data available since 1995 All methods and information used in the risk assessment have been updated to those that are currently approved or in the approval process for RFETS This final risk assessment was completed in close consultation with CDPHE and EPA Ecological risk is not specifically addressed in this risk assessment However, ecological risk

[1] Although a portion of the New Process Waste Lines (NPWL), RCRA Unit 374 3, exists within this area, the line was not included in this risk assessment because it is an aboveground line with no soil contamination expected

will be assessed in the Comprehensive Risk Assessment (CRA) and has been evaluated for watershed areas adjacent to the SEPs Ecological risk will be assessed within larger exposure units (EUs) to evaluate potential impacts to ecological receptor populations within their defined habitats

1.1 SITE DESCRIPTION

RFETS consists of an industrialized area of approximately 400 acres surrounded by an undeveloped Buffer Zone (BZ) of approximately 6,150 acres The SEP is located in the central portion of the Site on the northeastern side of the Industrial Area (IA) and consists of five dry (empty) solar evaporation ponds (Pond 207-A, 207-B North, 207-B Center, 207-B South, and Pond 207-C) The SEP AOC includes adjacent soil within the IA and outside the IA fence, as well as a portion of IHSS 121, RCRA Units 21 and 48, and PAC 900-1310 (Figure 1 1) A field investigation was performed for the SEP and adjacent areas The results are presented in Appendix A Any releases of contaminants into the environment that may have occurred from these units are within the AOC The total AOC area is approximately 33 3 acres with a pond surface area of 6 1 acres, as determined by Geographic Information System (GIS) analysis presented in Appendix B, Table 3

The SEP were constructed primarily to store and evaporate radioactive process wastes discharged from the OWPL These wastes contained elevated levels of nitrates, neutralized acidic wastes, aluminum hydroxide, sanitary sewage sludge, lithium metal, sodium nitrate, ferric chloride, lithium chloride, sulfuric acid, ammonium persulfates, hydrochloric acid, nitric acid, hexavalent chromium, and cyanide solutions

The ponds were initially constructed to contain wastewater within a liner inside a bermed area However, contaminated liquids infiltrated through the liner into subsurface soil Currently, a groundwater barrier and treatment system is in place to protect an adjacent watershed area from transport of groundwater contaminants A detailed description of the site location and general condition of the ponds is included in Sections 1 0 and 3 0 of the Phase I RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report for the SEP (DOE 1995)

1.2 REPORT ORGANIZATION

This document consists of the following sections and appendices that provide detailed information on various aspects of the risk assessment

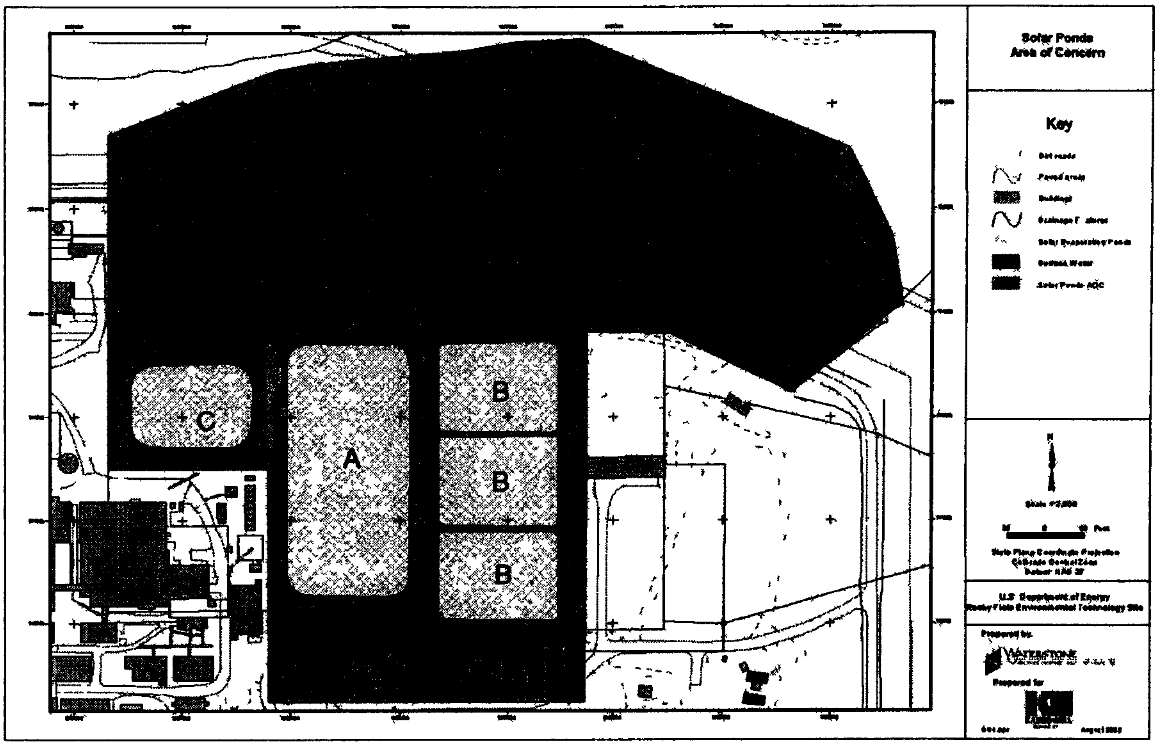

Figure 1.1 Solar Evaporation Ponds Area of Concern

Section 2.0, Selection of Contaminants of Concern: Describes the approach taken to screen and identify COCs for quantitative evaluation in the risk assessment, including a summary of the analytical data used and how the data were aggregated

Section 3.0, Exposure Assessment: Discusses the exposure scenarios evaluated in the risk assessment, presents the exposure point concentrations calculated for each COC in each exposure medium and exposure area, and describes the methodology and exposure parameters used to quantify intake from each exposure pathway to each receptor

Section 4.0, Toxicity Assessment: Describes the chemical-specific toxicity factors used in estimating noncarcinogenic and carcinogenic health risk resulting from exposure to chemicals and radionuclides

Section 5.0, Risk Characterization and Uncertainty Analysis : Presents the results of the quantitative risk assessment for each exposure scenario, including hazard index (HI)/hazard quotient (HQ) estimates and dose calculations for each receptor, and identifies the primary sources of uncertainty associated with the resulting risk estimates

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Section 6.0, Summary and Conclusions: Summarizes and draws conclusions from the evaluation of risk assessment results and primary findings

Section 7.0, References: Lists the literature cited in the risk assessment

Appendix A, Solar Evaporation Ponds Data and Background Comparison Tables and Figures: Documents data management and all chemical and radionuclide data used in the risk assessment Data are presented in tables by media, with a table of detection frequency and summary statistics Tables and figures for background comparisons are also included

Appendix B, AOC Area and Exposure Unit Size: Presents data on the development of the EU size and AOC area

Appendix C, Risk Calculations: Presents risk calculation results by chemical, as well as percent of total risk by media, pathway, and chemical

2.0 SELECTION OF CONTAMINANTS OF CONCERN

This section summarizes the analytical data, data aggregation assumptions, screening of potential contaminants of concern (PCOCs), and identification of COCs for quantitative evaluation in the risk assessment COCs in surface soil, subsurface soil, and pond liner materials were selected within the AOC

2.1 ANALYTICAL DATA ASSESSMENT

Analytical data from analysis of environmental samples collected during previous Phase I field investigations and Sitewide sampling programs were used to quantify contaminant concentrations present in the AOC, and select COCs for risk assessment The sampling and analytical programs followed approved work plans, and chemical analytical results were validated in accordance with EPA and RFETS data validation guidelines

SEP data used in the risk assessment consist of a compilation analytical results generated by on-site and off-site laboratories These data were originally stored in electronic format in the RFETS environmental Soil Water Database (SWD) The majority of these data were further processed through a series of data quality filters to ensure usability for risk assessment purposes Appendix A describes data preparation for the final database used in the risk assessment The data sets used for evaluation of surface soil, subsurface soil, and pond liner material are described below and presented in Appendix A, Tables A-1 through A-12

2.1.1 DATA QUALITY ASSESSMENT

This Data Quality Assessment (DQA) performed on the SEP data set is based on various criteria derived from EPA guidance, particularly those related to data verification and validation (V&V) A detailed DQA was also performed on the OU 4 IM/IRA data sets in 1995 (DOE 1995a), and those results are summarized herein Pertinent references are listed at the end of this report Quality control (QC) evaluations performed on the current SEP data set are documented within the Microsoft ACCESS database "OU4 RA-DQA mdb"

Verification and Validation of Results

Verification ensures that data produced and used by a project are documented and traceable in accordance with IA Sampling and Analysis Plan (IASAP) (DOE 2001) Validation consists of a technical review of data that directly support project decisions, such that any limitations of the data relative to project goals are stated V&V criteria include

- Chain-of-custody,

- Preservatıon and hold tımes,
- Instrument calıbratıons,
- Preparatıon blanks,
- Interference check samples (metals),
- Matrıx spıkes/matrıx spıke duplıcates (MS/MSDs),
- Laboratory control samples (LCSs),
- Fıeld duplıcate measurements,
- Chemıcal yıeld (radıochemıstry),
- Requıred quantıtatıon lımıts/mınımum detectable actıvıtıes (MDAs) (sensıtıvıty of chemıcal and radıochemıcal measurements, respectıvely), and
- Sample analysıs and preparatıon methods·

Evaluatıon of V&V crıterıa ensures that precısıon, accuracy, representatıveness, completeness, comparabılıty, and sensıtıvıty (PARCCS) parameters are satısfactory and wıthın tolerance lımıts establıshed for the project Satısfactory V&V of laboratory qualıty controls are captured through applıcatıon of valıdatıon "flags," or qualıfiers, applıed to ındıvıdual records Satısfactory V&V are ındıcated by a greater than 25 percent valıdatıon frequency for all data package submıttals, and a less than10 percent rejectıon of all data package records valıdated (DOE 2000)

Valıdatıon results are summarızed ın Table 2 1, and ındıcate that data qualıty for the project ıs excellent Valıdatıon frequencıes ranged from 53 to 86 percent per analytıcal suıte and far exceed the IASAP DQOs of greater than 25 percent for data packages Rejected records wıth an "R" valıdatıon code ranged from 0 5 to 2 5 percent of the total records for each analyte group Analytıcal results for the category of "Organıcs-mısc" refer to nontarget compounds not readıly classıfied wıthın the analytıcal suıtes gıven

Fıeld samplıng conducted for the OU 4 RFI/RI was performed under an approved Qualıty Assurance (QA) Plan, ıncludıng standard operatıng procedures (SOPs), QA addenda, and work plans (EG&G 1993) Several deficıency reports and assocıated correctıve actıon plans were also produced and ımplemented durıng the course of the project as an ıntegral part of the qualıty program None of the deficıencıes compromısed data qualıty (DOE 1995a, §II 3 6 1)

Table 2.1 Summary of SEP Data Set Validation Results

Validation Qualifier	Total of CAS Numbers	Number of Validated Records							
		Organics-misc	Anions	Metals	PCBs	Pesticides	Radionuclides	SVOCs	VOCs
Null	4,410	121	73	519	126	258	649	1,523	1,141
Y	141	35	-	-	-	-	106	-	-
Z	3,458	349	40	682	28	80	223	1,623	433
N	553	-	-	24	-	-	529	-	-
A	2,228	63	18	343	2	-	976	501	325
J	3,720	168	29	2,430	53	100	59	623	258
V	20,383	306	273	4,345	715	2,000	1,159	5,493	6,092
R	605	40	2	154	21	60	71	46	211
	-	-	-	-	-	-	-	-	-
Total Records	35,498	1,082	435	8,497	945	2,498	3,772	9,809	8,460
% Validated	76%	53%	74%	86%	84%	86%	60%	68%	81%
% Rejected	1 7%	3 7%	0 5%	1 8%	2 2%	2 4%	1 9%	0 5%	2 5%

V = valid without qualification

J = estimated (semiquantitative) value

A = acceptable with qualification

Null, N, Y, Z = not validated

R = rejected, do not use

Hard-copy records of previous SEP (OU 4) reports can be found in the RFETS Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Administrative Record Raw data, including V&V results and individual analytical data packages, are currently filed by report identification number (RIN) and maintained by Kaiser-Hill Company, L L C (K-H) Analytical Services Division (ASD) Older hard copies reside in the Lakewood, Colorado, Federal Center

Precision and Accuracy

Overall precision and accuracy for the SEP data set were evaluated Precision and accuracy have also been discussed and documented in the SEP IM/IRA (DOE 1995a) and summarized in this section

Precision of field sampling was adequate based on measurement of the relative percent difference (RPD) between duplicate and real samples A collection frequency of 10 percent was originally established for the project, although greater than 5 percent is generally considered adequate The actual collection frequency was 1 14, or approximately 7 percent

The RPD DQO for soil matrices was less than 40 percent, which was achieved for all analytical suites, including radionuclides, over 75 percent of the time

Field blanks collected during the project indicated that no false positives were present in the data set due to equipment cross-contamination

Representativeness

Samples collected for the project are representative based on their type, number, and location relative to the site-specific history (DOE 1995a) Other criteria that corroborate representativeness include

- Implementation of industry-standard chain-of-custody protocols,
- Compliance with sample preservation and hold times, and
- Compliance with documented and Site-approved sampling plans and procedures, including SW-846 analytical methods

Completeness

Sampling completeness was evaluated through the number and types of samples collected relative to project DQOs Specifically, were enough samples collected to meet established goals, and produce valid results, to make project decisions?

Table 2 2 presents the number of samples collected, relative to the analytical suites, for each environmental media

Table 2.2 Total Number of SEP Samples in Each Media by Analytical Suite

	Number of Samples Collected			
Analytical Group	Liner Surface	Surface Soil 0-0.5 Feet	Subsurface Soil 0.5-6.0 Feet	Subsurface Soil > 6.0 Feet
Metals	15	73	103	72
Radionuclides	15	72	118	133
PCBs	0	66	17	14
Pesticides	0	61	17	14
VOCs	0	68	98	102
SVOCs	67	67	27	14
Organics (misc)	0	71	101	72
Aroclors	-	-	72	59

Evaluation of data presented in Table 2 1 indicated that the minimum required percentages of validation were achieved for all sample types and analytical methods Of the percentages validated, less than 4 percent were rejected for any given analytical method This result is well below the maximum allowable rejection rate of 10 percent considered acceptable based on IASAP DQOs All rejected records were disqualified from use in the SEP risk assessment

Comparability

All results presented are comparable with nation-wide CERCLA data and U S Department of Energy (DOE) complex-wide environmental data This comparability is based on

- Use of standardized engineering units in the reporting of measurement results,
- Consistent sensitivities of measurements (generally less than or equal to one half corresponding action levels [ALs]), and
- Use of Site-approved procedures, work plans, and quality controls (for example, Contractual Statements of Work for laboratory analyses, [DOE 1995a])

Sensitivity

The adequacy of sensitivities for analytical methods were evaluated for all results Reporting limits and nondetect values were in units of micrograms per kilogram (µg/kg) or parts per billion (ppb) for organics, milligrams per kilogram (mg/kg) or parts per million (ppm) for metals, and picocuries per gram (pCi/g) for radionuclides Analyte detection limits and non-detect results were compared with PRGs based on WRW target risks of 1E-05 and an HQ of 1 0 on a record-by-record basis All results were less than one half the PRG value Adequate sensitivity was therefore achieved

Summary

Data quantity and quality are acceptable for risk assessment purposes, with the qualifications given, and based on the V&V criteria cited

2.1.2 Power Calculations

Sampling power was evaluated to statistically determine whether sufficient samples were collected to adequately characterize analyte concentrations within the AOC to support risk assessment In other words, given the estimate of the average analyte concentration and observed variance, it was determined whether the number of samples was adequate to identify an exceedance of ALs for the WRW at the 95% level of confidence It was assumed that samples were collected independently across the AOC for all sampled media, including liner material, surface soil, and subsurface soil All PCOCs found to be above screening risk levels were evaluated

Three methodologies were used to conduct power calculations that are specific to the type of concentration distributions observed

- Parametric EPA (1994) QA/G-4 Report for normally distributed results
- Lognormal Gilbert (1987) Equation 13 23 for lognormally distributed results
- Non-parametric Nuclear Regulatory Commission (NRC) et al (1997) Multi-Agency Radiological Survey and Site Investigation Manual (MARSSIM) Report §5 5 2 3 for non-parametric distributions

The QA/G-4 model (EPA 1994) was used to assess normally distributed analyte data and evaluate sample adequacy Gilbert equation 13 23 (1987) was used to estimate numbers of required samples for all analytes with lognormal distributions The MARSSIM model (NRC et al 1997) was used for all analytes with observed non-parametric distributions All three models were used to derive estimates of the averages and variances required to calculate the 95% upper confidence limits of the mean concentrations (95UCLs) Non-parametric estimates were derived from the resampling Bootstrap methodology (EPA 1997a, EPA 2001a, EPA 2002a)

Relative errors were derived primarily from the difference between the PRG or AL and the mean Secondary relative errors were determined based on the difference between the PRG and the upper 95% confidence limit of the mean A target risk of 1E-05 and HQ of 1 0 were used to select the appropriate PRGs to derive relative errors Relative errors derived from average and 95UCLs were used to bound sampling errors due to inherent heterogeneity of analytes in soil and liner materials to predict the number of samples required

Statistical testing for distributions was conducted at the 95% confidence level using EPA QA/G-9 guidance and the associated DataQuest software (EPA 2000a) Graphical output was also evaluated, including histograms and frequency distributions Section 2 3 5 presents a detailed evaluation of distributional testing for all PCOCs Section 2 3 3 presents results of the comparison of analyte maximum concentrations to PRGs

Liner Material

Radiological results appeared to be lognormal with leptokurtic, skewed-right distributions clustering about zero However, statistical testing did not confirm lognormality for liner analytes due to limited sample size of n = 15 The non-parametric MARSSIM method was therefore employed to evaluate sample power for liner analytes

Power calculation results indicated that a sufficient number of samples were collected for all liner analytes The results indicated that the difference between the mean or 95UCL and the respective PRGs is so great, that no additional samples would have to be collected A value of 13 was obtained for the MARSSIM test using the mean and 95UCLs, which is the default value when the relative shift is greater than 3 0 Lognormal power calculations using the Gilbert equation conducted for all liner analytes confirmed results of the non-parametric analysis and also indicated that no additional samples would be required

Surface Soil

Sample sizes for surface soil analytes ranged from 60 to 73 All analytes had non-parametric distributions except americium-241 and plutonium-239/240, which exhibited lognormal distributions Results of the MARSSIM power calculations indicated a default value of 13 for all analytes in surface soil Lognormal power calculations for americium-241 and plutonium-239/240 with lognormal distributions also indicated that no additional samples would be required A predicted value for americium-241 of two samples was obtained for the 95UCL and a value of one sample was obtained for plutonium-239/240 Low results for lognormal analytes indicates that the means and upper 95% confidence levels are well below the respective PRGs and no additional samples would have to be collected

Subsurface Soil

Subsurface soil was evaluated for sample adequacy using normal, lognormal, and non-parametric power calculations Actual sample sizes for subsurface soil analytes ranged from 95 to 118 Iron was the only analyte with a normal distribution Americium-241, plutonium-239/240, uranium-235, and uranium-234 were all assigned non-parametric distributions due to the presence of negative data Uranium-238 and all other analytes had observed lognormal distributions

A predicted sample size of one was obtained for iron using the EPA QA/G-4 model All lognormal power calculation results were also one All non-parametric power calculation results were 13 Low results for normal and lognormal analytes indicated that mean and upper 95% confidence levels were well below the respective PRGs for the WRW Non-parametric results were all at the default of 13 when the relative difference over the standard deviation is greater than 3 0 Predicted sample sizes for all subsurface soil analytes were therefore below the actual sample sizes collected at the SEP

Based on the results of the power calculations for all analytes in all SEP media, it was concluded that a sufficient number of samples were collected from the AOC to adequately quantify risk at 95% probability

2.2 SEGREGATION OF SAMPLES BY MEDIA

This section describes the samples collected by media, including pond liner, surface soil, and subsurface soil

2.2.1 Liner Material

A total of 15 pond liner material samples were collected in 1993 and 1995 These samples were analyzed for metals and radionuclides Analyses for organics were not requested because the liner materials were made of asphalt Sampling locations for the collection of pond liner materials are shown on Figure 2 1 All ponds were sampled, except the southernmost B-Series ponds However, all B-Series ponds received similar waste streams and contaminants

The pond liner data were aggregated separately and assessed using surface soil pathways Separation of liner materials provided critical information to risk management to evaluate possible remediation of this medium overlying surface soil No allowance was made for additions of clean fill over the liners

Four asphalt samples from Pond 207-C were collected and tested for RCRA toxicity characteristics using the Toxicity Characteristic Leaching Procedure (TCLP) Test Method 1311, specified by EPA in SW-846 (EPA 1996) Observed concentrations of arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver were well below regulatory limits Therefore, the SEP liner material were not classified as characteristic hazardous waste and are not subject to regulation under RCRA, Code of Colorado Regulations (CCR) 1007-3, Subpart C

2.2.2 Surface Soil

Most surface soil samples were collected using the Rocky Flats Plant (RFP) method, in which the top 2 inches (5 centimeters) of soil were collected in several locations within a plot and then composited Other samples were collected from the first interval of a borehole All samples having a beginning and ending depth between 0 and 6 inches were retained in the surface soil data set Surface soil for the ponds was considered to be within 0 to 6 inches of soil below the liners The majority of surface soil samples were collected from May through July 1994 The analytical parameters varied by location, but generally included metals, radionuclides, nitrates, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, and polychorinated biphenyls (PCBs) Surface soil sampling locations are shown on Figure 2 2

2.2.3 Subsurface Soil

Subsurface soil samples were collected from October 1987 through November 1993 in 2-to-6-foot composites, depending on sampling location However, samples collected for VOC analyses were not composited Laboratory analyses of subsurface soil samples generally included VOCs, SVOCs, metals, pesticides, PCBs, and radionuclides Subsurface data were divided into three categories (1) samples with beginning depths less than 6 feet and ending depths greater than 0 5 foot (Figure 2 3), (2) samples with beginning depths greater than 6 feet (Figure 2 4), and (3) samples with no depth data in the database (Figure 2 5) Only samples with starting depths less than six feet were used in the risk assessment, because receptors are unlikely to come in contact with soil below six feet Subsurface data with no depths were not used due to the uncertainty of actual sample depth These data are discussed in Section 2 3 7

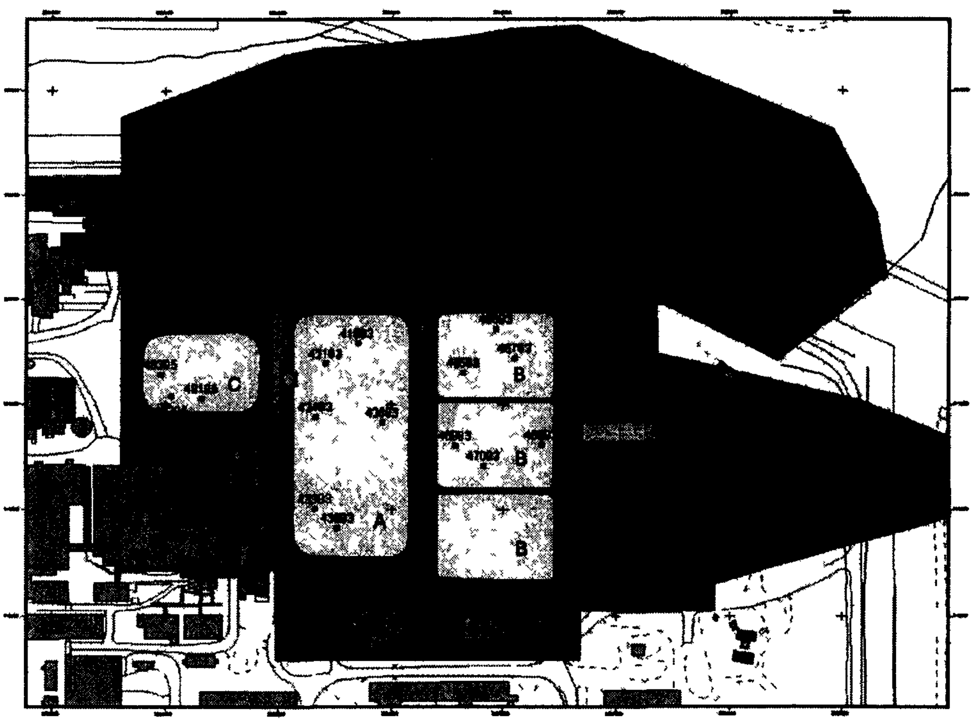

Figure 2.1 Pond Liner Sampling Locations

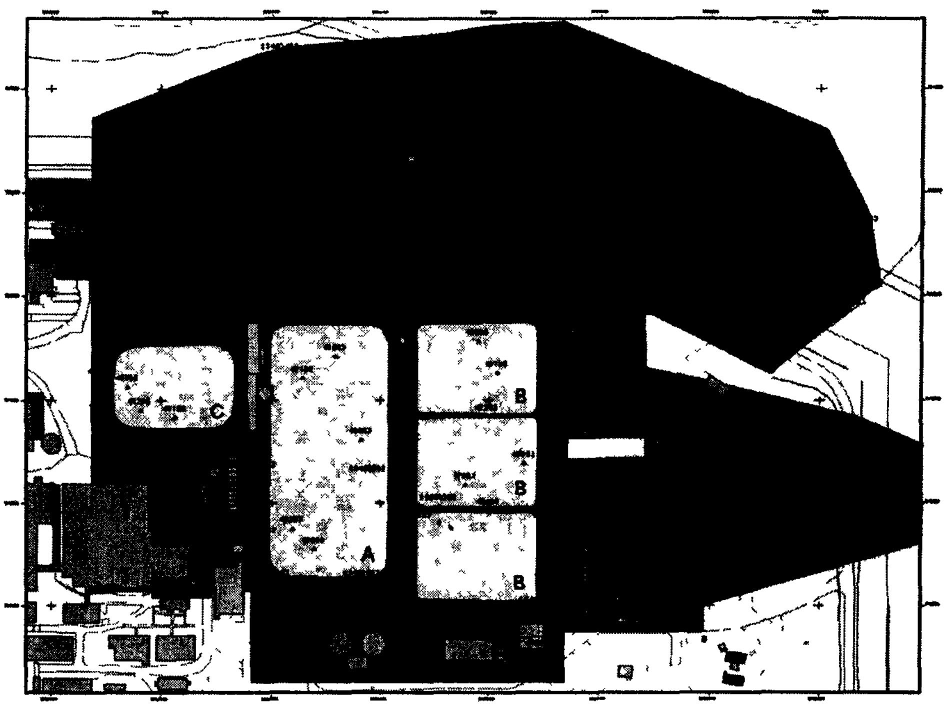

Figure 2.2 Surface Soil Sampling Locations

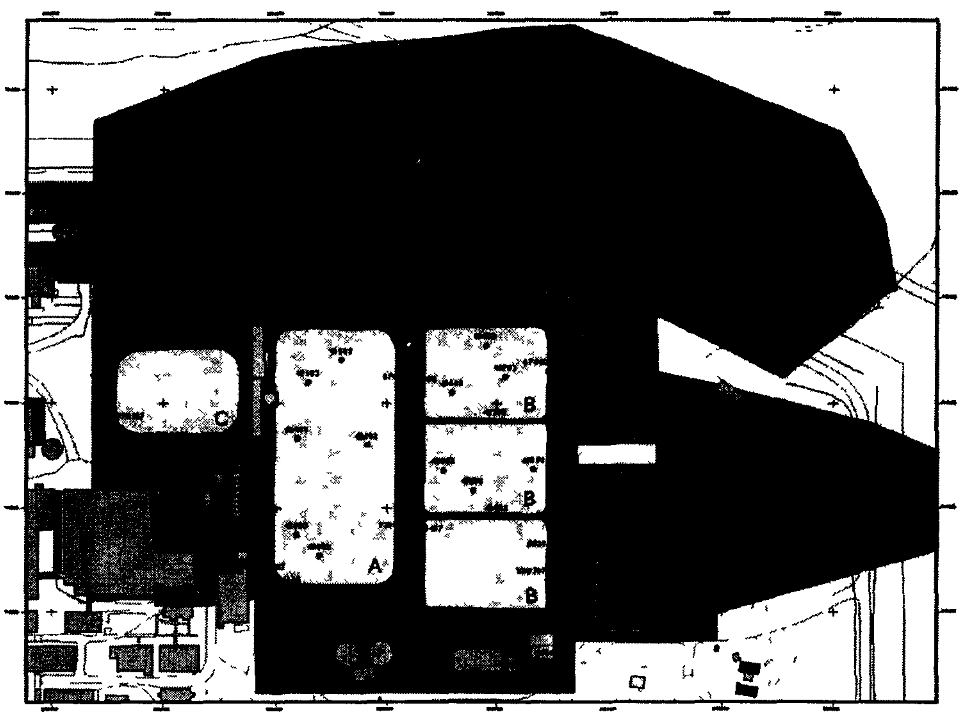

Figure 2.3 Subsurface Soil Sampling Locations (Beginning Depths Less Than 6 Feet)

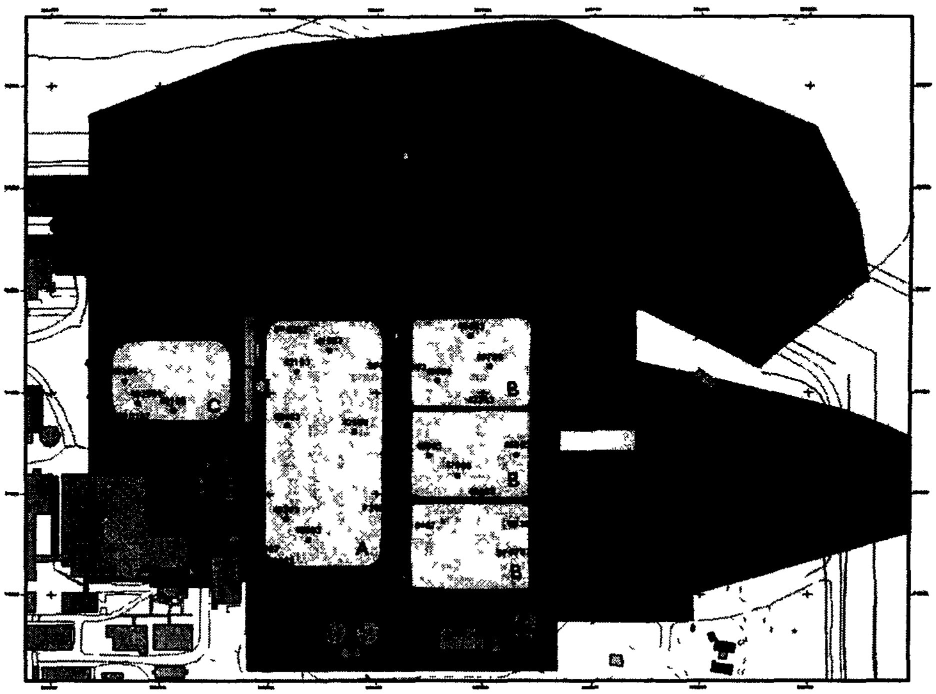

Figure 2.4 Subsurface Soil Sampling Locations (Beginning Depths Greater Than 6 Feet)

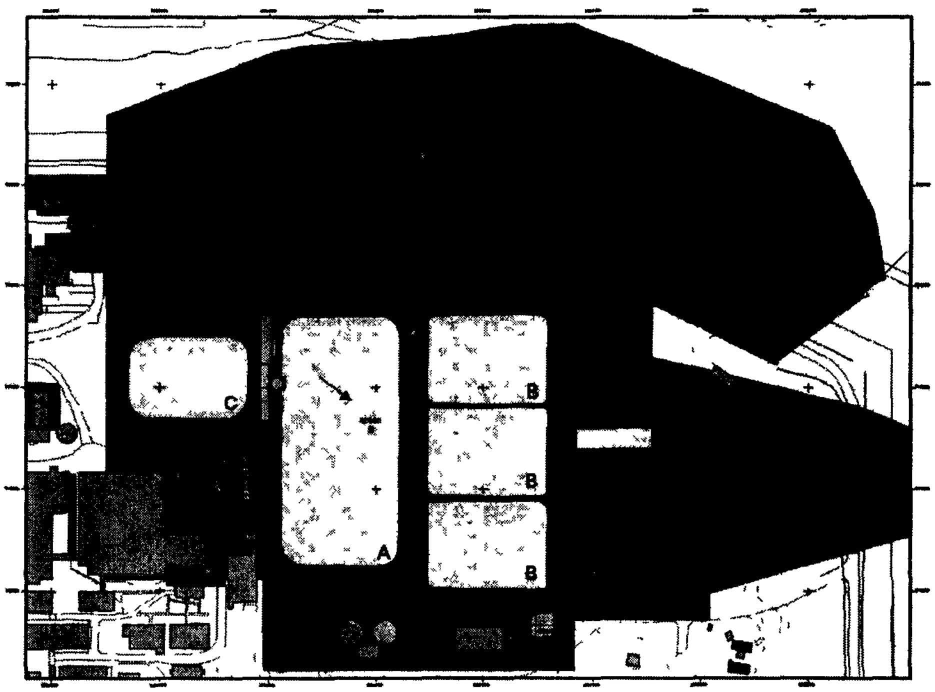

Figure 2.5 Subsurface Soil Sampling Locations (No Depths)

2.3 SELECTION OF CONTAMINANTS OF CONCERN

Samples within the AOC for surface soil, subsurface soil, and liner material were selected for use in the risk assessment The constituents in these media were the result of natural processes, precipitation or downwind deposition of particulates and aerosols from the solar ponds, anthropogenic background (including pond liner materials), leakage of fluids from the solar ponds and surrounding lines, and accidental releases of site-specific chemicals All analytes listed in the Action Levels and Standards Framework for Surface Water, Ground Water, and Soil (ALF) are considered PCOCs (DOE et al 1996) Summary information for all PCOCs is presented in Appendix A, Tables A-13 through A-20 All sample results from the AOC were pooled for each medium and the COCs selected The procedure used to screen the data and select COCs is documented below and shown on Figure 2 6

2.3.1 Essential Nutrients and Major Cations/Anions

Essential nutrients with no toxicity values in Integrated Risk Information System (IRIS) or Health Effects Assessment Summary Tables (HEAST) were compared to recommended daily allowances (RDAs), recommended daily intakes (RDIs), adequate intakes (AIs) or upper limit (UL) daily nutrient intakes, in accordance with EPA guidance (EPA 1989) Results of this comparison are shown in Table 2 3

Table 2.3 Comparison of Daily Intakes and Daily Allowances for Essential Nutrients Without Toxicity Values[a]

Element	Intake From Ingestion of 200 mg of Soil Per Day (mg/day)			Surface Soil Concentration (mg/kg)	
	Maximum	RDA/RDI/AI[2]	UL[2]	SEP Maximum	Western US Background Range[1]
Calcium	49 6	500-1,200	2,500	248,000	600 – 320,000
Magnesium	1 3	80-420	65-110	6,500	300-<100,000
Potassium	1 66	2,000-3,500	NA	8,310	1,900-63,000
Silicon	2 26	NA	NA	11,300	150,000-440,000
Sodium	0 7	500-2,400	NA	3,660	500-100,000

1 Shaklette and Boerngen 1984
2 RDA/RDI/AI/UL taken from NAS 2000
NA = Not available
ND = Not detected
a NAS = National Academy of Sciences (2000, 2002)

All essential nutrients in Table 2 3 were eliminated from further consideration based on calculated maximum intakes well below the RDAs, RDIs, ALs, and ULs Maximum intakes were also well within the range of background soil concentrations However, all essential nutrients with toxicity values were taken through the COC selection process

2.3.2 Data Aggregation and Calculation of Statistics

Data aggregation for the risk assessment was performed in accordance with guidelines developed by CDPHE, EPA Region VIII, and DOE The SEP AOC was delineated on the basis of the spatial extent of potential contaminants and known historical use The AOC encompasses the SEP and adjacent contaminated soil (Figure 1 1)

Sample concentrations for surface soil and the bermed soil surrounding the SEP were aggregated Liner sample data were aggregated separately from surface soil so that risks could be estimated for both media Subsurface soil data were aggregated for use in the risk assessment for samples with beginning depths at less than 6 feet Summary statistics were also generated for samples with beginning depths below 6 feet and for those records with no depth data These samples presented in Appendix A were not used in the risk assessment

Summary statistics were calculated for each data group, including detection frequency, mean contaminant concentrations, minimum concentrations, maximum concentrations, and standard deviation Summary statistics are presented in Appendix A, Tables A-13 through A-20 A summary of samples found to have irregular units that were excluded from the risk assessment is presented for each medium in Appendix A, Tables A 21 through A-23 The 95UCL was only calculated for COCs Additional details on calculating the exposure concentrations are provided in Section 3 0

2.3.3 Comparison to PRGs

PCOCs were screened relative to PRGs for the on-site WRW exposure scenario set to a 1E-06 risk level and an HQ of 0 1 (Appendix A, Tables A-13 through A-20) This was done to ensure that cumulative effects of PCOCs will be taken into consideration to meet the worker target risk limits of 1E-05 and HQ of 1 0 In addition, if detection frequency was less than 5 percent, a hot spot screen was conducted at 3E-05 risk to ensure that hot spots were not present The draft WRW PRGs developed by CDPHE using the radionuclide soil action levels (RSALs) exposure assumptions and parameters were used for the screen (CDPHE 2002) This is a conservative screen because the PRGs assumed indoor air exposure The SEP risk assessment is also conservative because the WRW PRGs assumed continuous gamma exposure for the occupational WRW receptor Correction of the PRGs used in this risk assessment for indoor air and continuous gamma exposures would lower the resulting risk (see Section 3 0)

Hexavalent chromium was deposited in the SEP However, it is unlikely that the chromium has remained in the oxidized state due to its instability in the soil environment The PRG value for chromium VI was used for conservatism in this risk assessment The maximum values observed from site samples, as reported in Appendix A, Tables A-13 through A-20, were directly compared to PRGs Those PCOCs with maximum concentrations below the corresponding PRGs were eliminated from further consideration The data were also compiled for subsurface soil below 6 feet, so they may be compared to shallow subsurface soil PCOCs with maximum values above the PRGs are shown in Tables 2 4 through 2 7

Table 2.4 PRG Screen Results for Surface Soil

Analyte	Minimum Conc.	Maximum Conc.	No. of Total Samples	No. of Detects	Detection Frequency (%)	PRG: 1E-6 or HQ=0.1	Max/PRG
Inorganics (mg/kg)							
Aluminum	5 45	32500	73	72	99	14763	2 20
Arsenic	0 31	7 5	72	70	97	2 17	3 46
Cadmium	0 135	382	73	43	59	95 5	4
Chromium	0 47	120	73	71	97	15 1	7 95
Manganese	1 1	7650	73	72	99	220	34 8
Organics (μg/kg)							
Benzo(a)pyrene	36	1700	67	37	55	349	4 87
Dibenz(a,h)anthracene	38	370	66	9	14	349	1 06
Radionuclides (pCi/g)							
Americium-241	0 011	130	69	69	100	3	44 6
Plutonium-239/240	0 013	56	60	60	100	7	8 42
Uranium-234	0 51	63 4	71	71	100	17 4	3 64
Uranium-235	-0 008	2 3	71	54	76	0 226	10 2
Uranium-238	0 31	27	72	72	100	1 03	26 1

Table 2.5 PRG Screen Results for Liner Materials

Analyte	Minimum Conc.	Maximum Conc.	No. of Total Samples	No. of Detects	Detection Frequency (%)	PRG: 1E-6 or HQ=0.1	Max/PRG
Inorganics (mg/kg)							
Chromium	5 7	37 5	15	15	100%	15 1	2 483
Radionuclides (pCi/g)							
Americium-241	0 003	8 188	15	9	60%	2 91	2 814
Uranium-235	0 018	0 27	15	10	67%	0 236	1 144
Uranium-238	0 52	2 68	15	15	100%	1 03	2 602

Table 2.6 PRG Screen Results for Subsurface Soil Above 6 Feet

Analyte	Minimum Conc.	Maximum Conc.	No. of Total Samples	No. of Detects	Detection Frequency (%)	PRG: 1E-6 or HQ=0.1	Max/PRG
Inorganics (mg/kg)							
Aluminum	2250	39100	102	102	100	14763	2 65
Arsenic	0 295	15 5	103	97	94	2 17	7 14
Barium	13 45	11600	102	101	99	1833	6 33
Cadmium	0 1	547	97	29	30	95 5	5 73
Chromium	3 8	56 9	102	102	100	15 1	3 77
Iron	3210	31100	102	102	100	30660	1 01
Manganese	43 6	1220	102	102	100	220	5 55
Organics (µg/kg)							
Benzo(a)pyrene	34	405	26	1	4	349	1 16
Radionuclides (pCi/g)							
Americium-241	-0 04	6 1	95	82	86	2 91	2 09
Plutonium-239/240	-0 06	19 78	98	81	83	6 65	2 97
Uranium-234	0	21	118	117	99	17 4	1 21
Uranium-235	0	0 87	99	71	72	0 226	3 86
Uranium-238	0 1	11 46	118	114	97	1 03	11 1

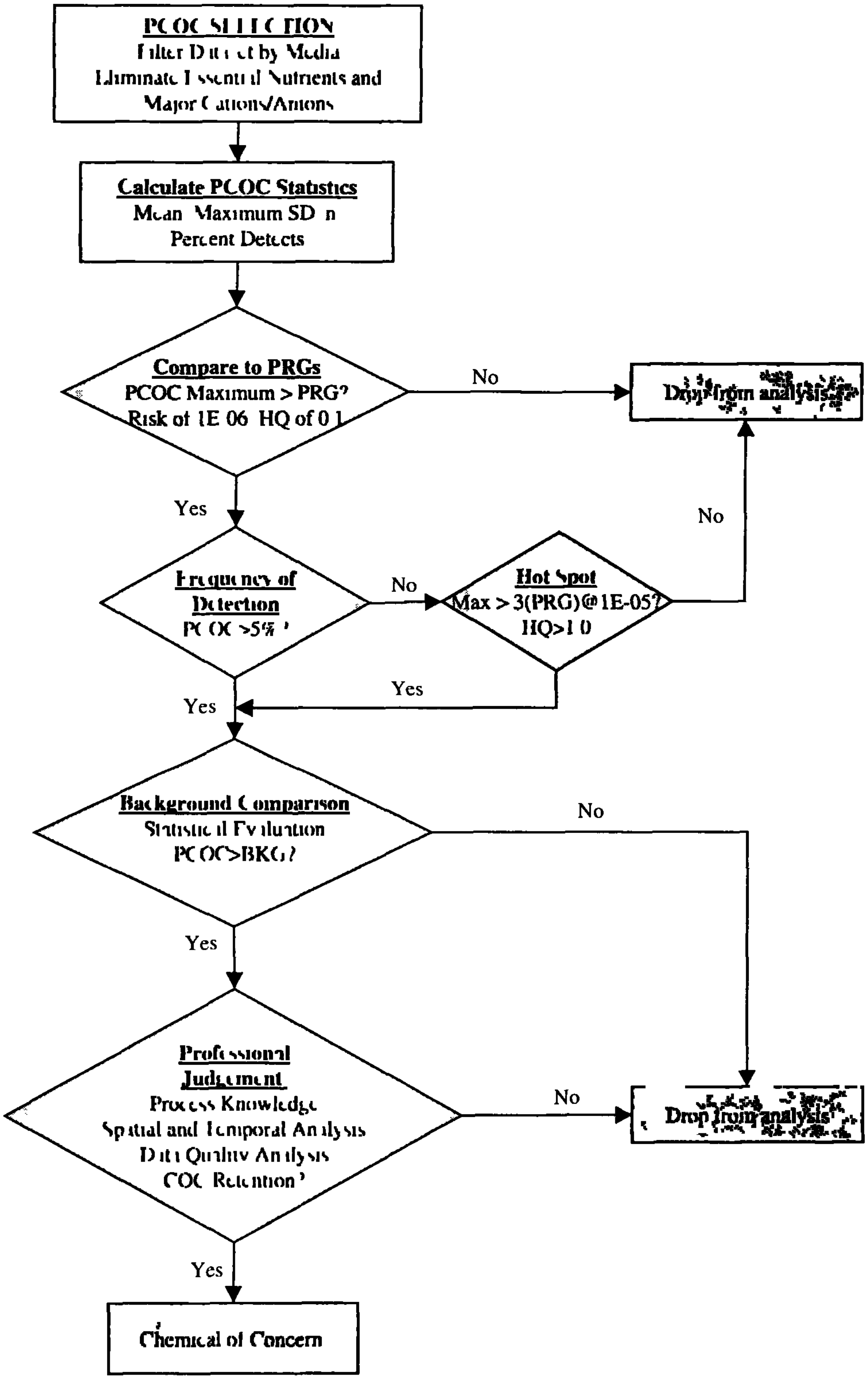

Figure 2 6 IHSS PCOC Screening Process

Table 2.7 PRG Screen Results for Subsurface Soil Below 6 feet

Analyte	Minimum Conc.	Maximum Conc.	No. of Total Samples	No. of Detects	Detection Frequency (%)	PRG: 1E-6 or HQ=0.1	Max/PRG
Inorganics (mg/kg)							
Aluminum	2160	42400	72	72	100	14763	2 872
Arsenic	0 19	24 6	72	67	93	2 17	11 336
Barium	9 7	4150	72	65	90	1833	2 264
Iron	1060	50800	72	71	99	30660	1 657
Manganese	21 5	3140	72	72	100	220	14 274
Radionuclides (pCi/g)							
Uranium-235	-0 005	0 383	71	43	61	0 226	1 698
Uranium-238	0 19	9 29	132	128	97	1 03	8 987

2.3.4 Frequency of Detection

All contaminants were evaluated for frequency of detection Rarely detected PCOCs with detection frequencies less than 5 percent and analytes with no detections were screened relative to three times the PRG at a risk of 1E-05 to ensure that the detection limits were not set too high to detect potentially hazardous concentrations present in hot spots Benzo(a)pyrene had a detection frequency of 4 percent (one detect, Table 2 6) in subsurface soil from 0 5 to 6 0 feet This PCOC will not be retained because the ratio of the maximum detection to the PRG at 1E-05 was less than 3, and the detection frequency was less than 5 percent Non-detected contaminants were not observed in surface soil or liner material with elevated detection limits greater than screening PRGs at 1E-06 or an HQ of 0 1 (Appendix A, Tables A-13 through A-20)

2.3.5 Data Distribution Testing

Distributional testing was performed for all PCOCs detected in liner materials, surface soil, and subsurface soil retained following the PRG and frequency screens Testing was conducted following EPA guidance and EPA QA/G-9 methods using the DataQuest Program (EPA 1992a, 1996, 2000a, 2002a) Data Quest includes six statistical tests for determining data distributions

- Shapiro-Wilk Test (S-W, test limited to n < 50, highly recommended),
- Fillibens Test (Fillibens, test limited to n < 100, highly recommended),
- Coefficient of Variation Test (CV, only for quick rejection of normality),
- Skewness and Kertosis Tests (S/K, n > 50, limited testing power),

- Studentized Range Test (S R , n < 1,000, limitations for nonnormal data), and
- Geary Test (Geary, verify with other test if n > 50, samples size > n = 100)

Three primary tests recommended by EPA were selected to test data distributions The Shapiro Wilk W-Test was used when samples sizes were below n = 50 as recommended by EPA The Fillibens Test was used for sample sizes from n = 50 to 100 and the Gearys Test was used for samples sizes above n = 100 as recommended by EPA Distribution testing results were evaluated and a final distribution type of normal, lognormal, or non-parametric was assigned to each PCOC in accordance with the UCL Method Flow Chart in the EPA guidance Calculating Exposure Point Concentrations at Hazardous Waste Sites (EPA 2002a) The assigned distribution was then used to quantify an appropriate upper 95UCL Test results were also compared to background distribution test results to determine the appropriate statistical test to compare SEP data to background data

Statistical comparisons to background were conducted using a non-parametric Mann-Whitney Rank Sum Test when SEP and background data had different assigned distributions or were both non-parametric, in other words, when distributions were not normally or lognormally distributed If SEP and background data had the same normal or lognormal distributions, then a Student's T-Test was used to compare PCOCs to background Lognormal data were log-transformed prior to conducting a standard T-Test Evaluation of 95% lognormal confidence intervals for SEP and background data was also conducted Overlap of 95% confidence intervals indicated that SEP data were within the range of natural background

Liner Data Evaluation

Due to the uncertainties associated with small sample sizes of n = 15 for all liner analytes, specific distributional testing was not performed Maximum observed concentrations for all liner analytes were, therefore, used to conservatively quantify risk rather than derive 95UCLs based on limited distributional information

Surface Soil Data Evaluation

Surface soil data ranging in sample size from 60 to 73 were evaluated for each PCOC with a maximum concentration above the WRW PRG and a frequency above 5 percent These PCOCs included aluminum, arsenic, cadmium, chromium, manganese, americium-241, plutonium-239/240, uranium-234, uranium-235, and uranium-238 In addition, benzo(a)pyrene and dibenzo(a,h)anthracene were evaluated All other PCOCs were eliminated in the PRG and frequency screens Table 2 8 presents the distributional testing results

All inorganic analyte data for surface soil were found to have non-parametric distributions Benzo(a)pyrene was found to have a lognormal distribution Americium-241 and plutonium-239/240 were found to have lognormal distributions All remaining radionuclides had non-parametric distributions Table 2 9 presents distributional testing results for background surface soil analytes Background data distributions for inorganic analytes corresponding to SEP surface soil PCOCs were predominantly normal, with the exception of cadmium with a non-parametric distribution Background americium-241 was also assigned a normal distribution However, plutonium-239/240 and uranium-235 were found to be lognormal and the remaining uranium isotopes were found to be non-parametric

Table 2.8 Summary of Distribution Testing for SEP Surface Soil PCOCs

PCOC (n)	Distribution Test Results (alpha = 0.05)		
	Normality Test	Lognormality Test	Final Distribution
	Fillibens	Fillibens	
Aluminum (73)	No	No	NP
Arsenic (72)	No	No	NP
Cadmium (73)	No	No	NP
Chromium (73)	No	No	NP
Manganese (73)	No	No	NP
Benzo(a)pyrene (67)	No	Yes	Log
Dibenz(a,h)anthracene (66)	No	No	NP
Americium-241(69)	No	Yes	Log
Plutonium-239 (60)	No	Yes	Log
Uranium-234 (72)	No	No	NP
Uranium-235 (70)	No	No	NP
Uranium-238 (71)	No	No	NP

NP = non-parametric distribution
Log = lognormal distribution

Table 2.9 Summary of Distribution Testing for SEP Background Surface Soil

PCOC(n)	Distribution Test Results (alpha = 0.05)				
	Normality Test		Lognormality Test		Final Distribution
	S-W	Fillibens	S-W	Fillibens	
Aluminum (20)	Yes		Yes		Nor
Arsenic (20)	Yes		Yes		Nor
Cadmium (20)	No		No		NP
Chromium (20)	Yes		Yes		Nor
Manganese (20)	Yes		Yes		Nor
Americium-241 (50)	NA	Yes	NA	No	Nor
Plutonium-239 (50)	NA	No	NA	Yes	Log
Uranium-234 (20)	No		No		NP
Uranium-235 (20)	No		Yes		Log
Uranium-238 (20)	No		No		NP

NP = non-parametric distribution
Nor = normal distribution
Log = lognormal distribution
NA = not applicable, S-W Test limited to samples sizes less than 50

Subsurface Soil Data Evaluation

Subsurface soil sample results ranging in sample size from 95 to 118 were evaluated for distributional type, as shown in Table 2 10, for all PCOCs retained in the PRG and frequency screens Inorganics were lognormally distributed, with the exception of iron which exhibited a normal distribution However, all radionuclides, with the exception of uranium-238, were non-parametric Uranium-238 exhibited a lognormal distribution Most radionuclides could not be evaluated for lognormality due to the presence of zero and negative concentrations and were assigned non-parametric distributions

Table 2.10 Summary of Distribution Testing for SEP Subsurface Soil PCOCs

PCOC (n)	Distribution Test Result (alpha = 0.05)				
	Normality Test		Lognormality Test		Final Distribution
	Filliben's	Geary	Filliben's	Geary	
Aluminum (102)	NA	No	NA	Yes	Log
Arsenic (103)	NA	No	NA	Yes	Log
Barium (102)	NA	No	NA	Yes	Log
Cadmium (97)	No	NA	Yes	NA	Log
Chromium (102)	NA	No	NA	Yes	Log
Iron (102)	NA	Yes	NA	Yes	NOR
Manganese (102)	NA	No	NA	Yes	Log
Americium-241 (95)	No	NA	NC	NA/NC	NP
Plutonium-239 (98)	No	NA	NC	NA, NC	NP
Uranium-234 (118)	NA	No	NA	NC	NP
Uranium-235 (99)	No	NA	NC	NA,NC	NP
Uranium-238 (118)	NA	No	NA	Yes	Log

NA = Fillibens Test limited to n < 100 and Gearys Test limited to n > 100
NC = not calculated due to zero and negative concentrations
NP = non-parametric distribution
Log = lognormal distribution
NOR = normal distribution

Table 2 11 presents distributional testing results for background analytes corresponding to PCOCs in SEP subsurface soil Aluminum, arsenic, barium, and cadmium had lognormal distributions for both background and SEP data All other background analytes in Table 2 11 exhibited non-parametric distributions Americium-241, plutonium-239/240, and uranium-235 could not be log-transformed due to the presence of zero and negative concentrations

Subsurface soil PCOCs exhibited more lognormal distributions compared to surface soil PCOCs that were primarily non-parametric This could be due to the presence of contamination mixed with background concentrations in surface media, as opposed to a predominantly background population present in subsurface soil

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Table 2.11 Summary of Distribution Testing for Background Subsurface Soil PCOCs[1]

PCOC (n)	Distribution Test Result (alpha = 0.05)		
	Normality Test Fillibens	Lognormality Test Fillibens	Final Distribution
Aluminum (98)	No	Yes	Log
Arsenic (99)	No	Yes	Log
Barium (99)	No	Yes	Log
Cadmium (81)	No	Yes	Log
Chromium (99)	No	No	NP
Iron (99)	No	No	NP
Manganese (99)	No	No	NP
Americium-241 (28)	NA	NC	NP
Plutonium-239 (99)	No	NC	NP
Uranium-234 (99)	No	No	NP
Uranium-235 (99)	No	NC	NP
Uranium-238 (99)	No	No	NP

[1]Subsurface soil data from upper stratigraphic unit
NA = Not applicable for n < 50 samples Shapiro-Wilk Test was conducted
NC = not calculated due to zero and negative concentrations
NP = non-parametric distribution
Log = lognormal distribution

2.3.6 Statistical Comparison to Background

Analytical results for metals and radionuclides above WRW PRGs in surface soil, subsurface soil, and liner material at the SEP were statistically compared to background concentrations Background data were taken from DOE (1995b and 1993) for local surface and subsurface soil, respectively Liner analyte data were not compared to background due to the limited sample size of n = 15 and the difficulty in ascertaining the true distribution All four liner PCOCs were therefore carried into the risk assessment without further screening

Data distribution testing was discussed in Section 2 3 5 for all PCOCs retained after the PRG screen for all SEP media Statistical comparison of SEP media data to background data was conducted, based on distribution testing results, to ascertain the possible presence of SEP analyte concentrations above natural background If SEP media data and background data had different distributions or both had non-parametric distributions, then a non-parametric Mann-Whitney U-Test was used for the comparison If both background and SEP media data had normal or lognormal distributions, then a specific T-Test or a comparison of lognormal 95% confidence intervals were used, respectively When necessary, lognormal data were log-transformed prior to conducting a T-Test A comparison of lognormal 95% confidence intervals for SEP analyte data to background data was conducted to evaluate whether SEP data were within the range of background However, this test was not considered conclusive and was used in conjunction with the Mann-Whitney U-Test and the T-Test to screen PCOCs in the background comparison screen The non-parametric Mann-Whitney U-Test and T-Tests were used to test for differences between the medians and means of two independent samples with an Alternative Hypothesis SEP > Background, p-value = 0 05

Statistical testing versus background was performed for all PCOCs with maximum concentrations above PRGs as shown in Tables 2 4 through 2 6 Comparative statistics were run, using the Excel™ add-in program Analyze-it™, for the AOC and background data for each analyte and medium (Appendix A) A box plot comparison was completed to visually compare each pair of populations Detailed statistical results and box plots are shown in Appendix A, Tables A-24 through A-79 Results of the statistical comparison to background are summarized in Table 2 12 and discussed below All retained PCOCs are in boldface in Table 2 13

Liner Material: All liner PCOCs including chromium, americium-241, plutonium-239/240, and uranium-238 were not compared to background and retained in the final risk assessment as shown in Table 2 13 Retention of all liner PCOCs is considered conservative because non-parametric testing indicated that chromium and uranium-238 would be eliminated

Surface Soil: All PCOCs from SEP surface soil were evaluated and found to either have different distributions relative to background distributions or were both non-parametric (Section 2 3 5) The only exception to this observation was plutonium-239/240, which had lognormal distributions for SEP and background data Therefore, with the exception of plutonium-239/240, all statistical comparisons to background were conducted using the non-parametric Mann-Whitney U-Test

Aluminum, arsenic, and manganese were determined to be significantly less than background at the 0 05 level of significance and were therefore eliminated from further consideration as PCOCs (Table 2 13) The lognormal 95% confidence interval for plutonium-239/240 from the SEP (3 3-16 5 pCi/g) was calculated and found to exceed the lognormal confidence interval for background (0 035-0 043 pCi/g), as shown in Table 2 13 Cadmium, chromium, and all radionuclides were retained as PCOCs as shown in Table 2 13 A T-Test was also conducted on the log-transformed data for plutonium-239/240 and found to be significant at the 0 05 level of significance (P<0 0001)

Subsurface Soils: In general, SEP subsurface soil analytes were found to have non-parametric or lognormal data distributions that were similar to background distributions

Chromium, iron, and manganese were determined to be less than or equal to background using the Mann-Whitney U-test and will not be considered further Aluminum, arsenic, barium, and cadmium all exhibited lognormal distributions for both SEP subsurface soil and background soil data The lognormal 95% confidence intervals for SEP subsurface soil and background data for these four analytes are listed in Table 2 12

Table 2.12 Lognormal Confidence Intervals for Subsurface Analytes

PCOC	Lognormal Confidence Interval	
	SEP Soil	Background Soil
Aluminum	11619 to 14010	11484 to 14708
Arsenic	4 38 to 5 86	3 56 to 4 50
Cadmium	3 6 to 9 6	0 54 to 0 72
Barium	102 to 138	85 2 to 107

Table 2.13 Statistical Comparison of SEP and Background Data

Analyte	AOC (n)	BKG (n)	Statistical Result[a] U-Test P-Value (T-Test P-Value)	>BKG Alpha= 0.05
Liner Materials				
Chromium	15	20	**0.1118**	Yes
Americium-241	15	50	**0.001**	Yes
Uranium-235	15	20	**(0.0003)**	Yes
Uranium-238	15	20	**0.0966**	Yes
Surface Soil				
Aluminum	73	20	0 541	No
Arsenic	72	20	1 000	No
Cadmium	**73**	**20**	**0.0009**	Yes
Chromium	**73**	**20**	**0.0017**	Yes
Manganese	73	20	0 9932	No
Americium-241	**69**	**50**	**<0.0001**	Yes
Plutonium-239/240	**60**	**50**	**(0.0001)**	Yes
Uranium-234	**71**	**20**	**0.0002**	Yes
Uranium-235	**71**	**20**	**0.0028**	Yes
Uranium-238	**72**	**20**	**0.0014**	Yes
Subsurface Soil				
Aluminum	102	98	(0 199)	No
Arsenic	**103**	**99**	**(0.0012)**	Yes
Barium	102	99	(0 073)	No
Cadmium	**97**	**81**	**(0.0001)**	Yes

Analyte	AOC (n)	BKG (n)	Statistical Result[a] U-Test P-Value (T-Test P-Value)	>BKG Alpha= 0.05
Chromium	102	99	0 5645	No
Iron	102	99	0 9470	No
Manganese	102	99	0 6043	No
Americium-241	**95**	**28**	**<0.0001**	**Yes**
Plutonium-239/240	**98**	**99**	**<0.0001**	**Yes**
Uranium-234	**118**	**99**	**<0.0001**	**Yes**
Uranium-235	**99**	**99**	**<0.0001**	**Yes**
Uranium-238	**118**	**99**	**<0.0001**	**Yes**

(a) Statistical results are presented for the U-Test unless in parenthesis for the T-Test using log-transformed data

The Mann-Whitney Rank Sum Test was used unless a T-Test was conducted on log-transformed data as shown for all results in parentheses

Liner material was compared to surface soil background levels

The 95% confidence intervals overlapped and supported the decision to eliminate aluminum, arsenic, and barium as PCOCs However, the 95% confidence intervals for cadmium from the SEP were found to exceed the corresponding background interval T-tests were also conducted for these four analytes using log-transformed data Results are shown in Table 2 12 and indicated that aluminum (P=0 199) and barium (P= 0 073) were less than background at the 95% confidence level The non-parametric Mann-Whitney test results also indicated that aluminum (P=0 1594) and barium (P=0 0677) were less than background at the 95% confidence level (Table 2 12) Aluminum and barium were therefore eliminated from further consideration as PCOCs

However, arsenic was significantly higher than background with a T-Test evaluation of log-transformed data (P=0 0012) and the non-parametric Mann-Whitney U-Test (P=0 0003) Arsenic was therefore retained as a PCOC

Cadmium was also evaluated with a T-Test using log-transformed data from the SEP and found to be significantly greater than background at the 0 05 level of significance (P<0 0001) Cadmium was therefore retained as a PCOC All radionuclides were also retained based on significant results greater than background using the non-parametric Mann-Whitney U-Test

2.3.7 Application of Professional Judgement

The possible elimination of dibenzo(a,h)anthracene and benzo(a)pyrene in SEP surface soil and arsenic in subsurface soil was evaluated in this section Dibenzo(a,h)anthracene and benzo(a)pyrene are members of the group of ubiquitous polyaromatic hydrocarbons that occur due to combustion, in engine exhaust and asphalt There is no information suggesting that either compound was released due to activities at the SEP site There is no pattern of contamination that suggests these compounds are a result of a waste release, therefore, dibenzo(a,h)anthracene and benzo(a)pyrene are not considered COCs

Maximum concentrations for dibenzo(a,h)anthracene and benzo(a)pyrene in surface soil are above the PRG screening levels for the WRW (Table 2 3) However, Table A-2 (Appendix A) shows that there were no unqualified detections, 9 "J" estimated detections, and 57 "U" non-detections for dibenzo(a,h)anthracene All estimated concentrations for dibenzo(a,h)anthracene were below their respective detection limits Benzo(a)pyrene had 5 unqualified detections, 32 "J" results below the detection limit, and 30 "U" nondetections All estimated concentrations for benzo(a)pyrene were below their respective detection limits

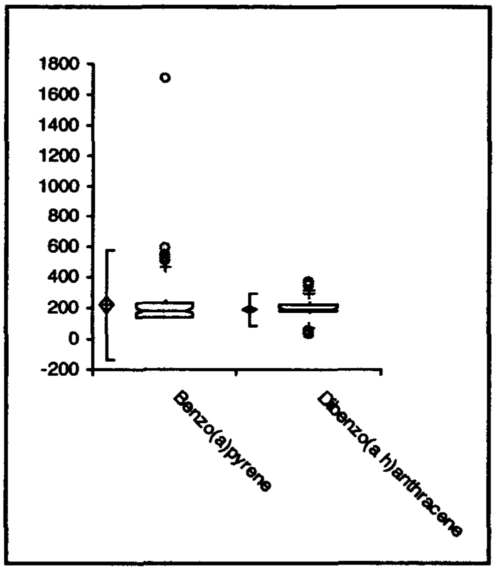

Figure 2.7 Box Plots

Figure 2 7 shows the box plots for these compounds The plot for benzo(a)pyrene suggests that a single hit above detection limits was observed

The WRW PRG at 1E-06 for dibenzo(a,h)anthracene is 0 348 mg/kg The detection limit ranged from 0 330 to 0 740 mg/kg, with a mean of 0 413 mg/kg The nine J-qualified (estimated) values were below the detection limit and ranged from 0 038 to 0 21 mg/kg The estimated values are all well below the PRG

The WRW PRG at 1E-06 for benzo(a)pyrene is 0 348 mg/kg The detection limit ranged from 0 330 to 0 740 mg/kg, with a mean of 0 411 mg/kg The five detections ranged from 0 47 to 1 7 mg/kg The 95UCL for benzo(a)pyrene, calculated using the bootstrap methodology discussed in Section 3 0, is 0 290 mg/kg, which is also well below the PRG

Arsenic was determined to be significantly greater than background at the alpha=0 05 level in the 0 5-to-6-foot layer of subsurface soil using the non-parametric Mann-Whitney Test and an independent T-Test on log-transformed data A comparison of the 95% lognormal confidence intervals indicated the populations are the same Figure A-55 (Appendix A) shows that the SEP results are all well below the maximum background result of 41 8 mg/kg The maximum SEP arsenic concentration was 15 5 mg/kg The range for surficial soil of the western United States is 0 1 to 97 mg/kg with a geometric mean of 5 5 mg/kg and an arithmetic mean of 7 mg/kg (Shacklette and Boerngen 1984) The arithmetic means for subsurface soil in the SEP AOC and background are 4 7 and 3 6 mg/kg, respectively Both are below the geometric and arithmetic means for western U S soil The arithmetic 95UCLs are 5 3 mg/kg for the SEP and 4 9 mg/kg for background The lognormal 95UCLs are 5 9 mg/kg for the AOC and 4 5 for background Arsenic concentrations in surface soil and liner materials were below background levels The arsenic concentrations in subsurface soil are considered to be well within the natural variation in soil and, as such, arsenic will not be carried forward as a COC

2.3.8 Excluded Data

The following data were specifically excluded from the risk assessment

- Subsurface soil data with beginning depths greater than 6 feet (Appendix A, Tables A-9 through A-11, A-14, and A18),
- Soil data with null depth fields (Appendix A, Tables A-12, A-16, and A-20),
- Data for all media that had irregular units (Appendix A, Tables A-21 through A-23),
- Data for compounds not included on the ALF list of analytes, and
- Data without EPA toxicity values

These excluded data are presented in Appendix C

Summary statistics for data from greater than 6 feet (Appendix A, Table A-15) show that maximum values for aluminum, arsenic, iron, and manganese were higher than in data from less than 6 feet It is likely that this is due to geologic and soil weathering processes, because these increases include the major soil constituents aluminum, iron, and, manganese The maximum for arsenic increases from 15 5 to 24 6 mg/kg Both arsenic concentrations are much lower than the subsurface background maximum of 41 8 mg/kg No organics in the greater-than-6-foot data set had values greater than their respective PRGs

Data with null depth fields were from only two locations (Figure 2 5) and included only organic analytes No maximum values for these data exceeded PRGs

The third type of data excluded from the assessment were data with irregular units Rather than make changes to the units without clear justification, it was decided to censor the data In other words, it was not possible to definitively correct the number or the associated units in each specific case However, excluded data did not include any significantly high values (Appendix A, Tables A-21 through A-23)

Only compounds listed in ALF were included in the risk assessment per agreement with the regulatory agencies (DOE et al 1996) All analytes listed in ALF have toxicity factors Appendix A, Tables A-2 15 through A-2 17 list those analytes with no PRGs in ALF that were detected in liner materials, surface soil, and subsurface soil Most analytes without PRGs were essential nutrients, radionuclides without any documented site use, or organics with no historical on-site use In addition, thallium and titanium were detected but have no PRGs or any known history of release at the site

2.3.9 Final Contaminants of Concern

Final COCs were selected for all SEP media based on previously discussed information, data evaluations, and screening processes Results of the COC screening for inorganics, organics, and radionuclides present in liner materials, surface soil, and subsurface soil are summarized in Table 2 14 Final COCs were retained in the quantitative risk assessment to quantify potential impacts to receptors for each exposure scenario

Table 2.14 Final Selected COC

Analyte	CAS Number	Total No. of Samples	Detection Frequency (%)
Surface Soil			
Cadmium	7440-43-9	73	59
Chromium	7440-47-3	73	97
Americium-241	14596-10-2	69	100
Plutonium-239/240	10-12-8	60	100
Uranium-234	11-08-5	71	100
Uranium-238	7440-61-1	72	100
Uranium-235	15117-96-1	71	76
Subsurface Soil			
Cadmium	7440-43-9	97	30
Americium-241	14596-10-2	95	86

Analyte	CAS Number	Total No. of Samples	Detection Frequency (%)
Plutonium-239/240	10-12-8	98	83
Uranium-234	11-08-5	236	50
Uranium-235	15117-96-1	99	72
Uranium-238	7440-61-1	118	97
Liner Materials			
Chromium	7440-47-3	15	100
Americium-241	14596-10-2	15	60
Uranium-235	15117-96-1	15	67
Uranium-238	7440-61-1	15	100

Selected COCs in liner materials were chromium, americium-241, uranium-235, and uranium-238 Radionuclides detected in liner materials generally had lower activities compared to surface and subsurface soil Selected COCs in surface soil were cadmium, chromium, americium-241, plutonium-239/240, uranium-234, uranium-235, and uranium-238 Selected COCs in subsurface soil were cadmium, americium-241, plutonium-239/240, uranium-234, uranium-235, and uranium-238 All radionuclides were therefore selected for both surface and subsurface soil

3.0 EXPOSURE ASSESSMENT

This section discusses exposure scenarios evaluated in the risk assessment and presents exposure point concentrations calculated for each COC in each exposure medium and exposure area The methodology and exposure parameters used to quantify contaminant intake for each exposure pathway are also presented

3.1 FUTURE ON-SITE LAND USE

Future on-site land use at RFETS includes environmental restoration, decontamination and decommissioning, and transfer of jurisdiction to the U S Fish and Wildlife Service for use as a wildlife refuge, in accordance with the Rocky Flats National Wildlife Refuge Act of 2001 The federal government will be responsible for conducting future environmental monitoring activities at the Site The refuge is currently envisioned to have minimal maintenance following remediation, however, refuge workers are assumed to be present on-site for most of the year and engaged in refuge maintenance and ecological work activities Residential development is not considered a foreseeable or reasonable future land use scenario and was excluded from the risk assessment

3.2 EXPOSURE PATHWAYS AND RECEPTORS

A complete exposure pathway requires a chemical source, chemical release mechanism, environmental transport medium, exposure point, and human intake route If one of these elements is lacking, the pathway is incomplete and human exposures will not occur Exposure to groundwater is an example of an incomplete pathway for the WRW because there is no human intake of contaminants Incomplete pathways were therefore not evaluated in the risk assessment Exposure pathways selected for quantitative evaluation in the risk assessment are listed below

3.2.1 Future On-Site WRW

The WRW will be primarily exposed to incidental ingestion of surface water, soil, and sediments, inhalation of volatiles and particulates, and external exposure to beta and gamma radiation from radionuclides present in surface soil The worker will also be exposed to subsurface materials during limited digging activities and dermal contact with surface and subsurface soil

The exposure scenario assumes that the WRW will be located in an office on an uncontaminated site 50 percent of each day during a standard work week of 5 days per week The remaining time on site will be spent outdoors across the Site It is assumed that this receptor will be exposed to residual contaminants in the IA, as well as all other on-site locations following remediation The WRW will conduct some percentage of field work that will result in exposure to residual contaminated surface soil, subsurface soil, sediments, and surface water

Figure 3 1 shows the Site conceptual model of potential human exposure pathways for the WRW The model is a schematic representation of the contaminant sources, contaminant release mechanisms, environmental transport media, and human exposure pathways for the SEP This model identifies complete exposure pathways that will be evaluated for quantitative risk assessment, as well as those pathways that are incomplete or do not warrant quantitative assessment because they would not contribute measurably to the estimate of overall risk

3.2.2 Significant Exposure Pathways

Several exposure pathways were considered significant and used to quantify risk to the WRW Incidental ingestion of surface water and sediments are not complete pathways within the AOC, but were included to estimate all sources of intake for the WRW from the general area surrounding the SEP Groundwater transport pathways were not evaluated because an existing barrier system is in place to intercept groundwater contaminants prior to contact with surface water

- Inhalation of airborne surface soil particulates,
- Inhalation of liner materials,
- Incidental ingestion of surface soils,
- Incidental ingestion of subsurface soils,
- Dermal exposure to surface soils,
- Dermal exposure to subsurface soils, and
- External radiation exposure

3.2.3 Insignificant Exposure Pathways

The following exposure pathways are incomplete for the SEP AOC, and were not quantitatively addressed in this risk assessment

- Ingestion of fish in RFETS surface water Surface water is not present at the SEP and on-site fishing is prohibited
- Ingestion of livestock Beef ingestion will not occur under the wildlife refuge land use
- Groundwater ingestion Shallow groundwater is not sufficiently productive for domestic well production
- Inhalation of VOCs released to outdoor air through volatilization from the soil VOCs were not identified as COCs during the selection process for the SEP
- Ingestion of homegrown produce Gardening will not occur under the wildlife refuge land use
- Dermal contact with surface water and sediments Dermal exposure pathways are considered complete for other areas of RFETS, but are not significant within the AOC

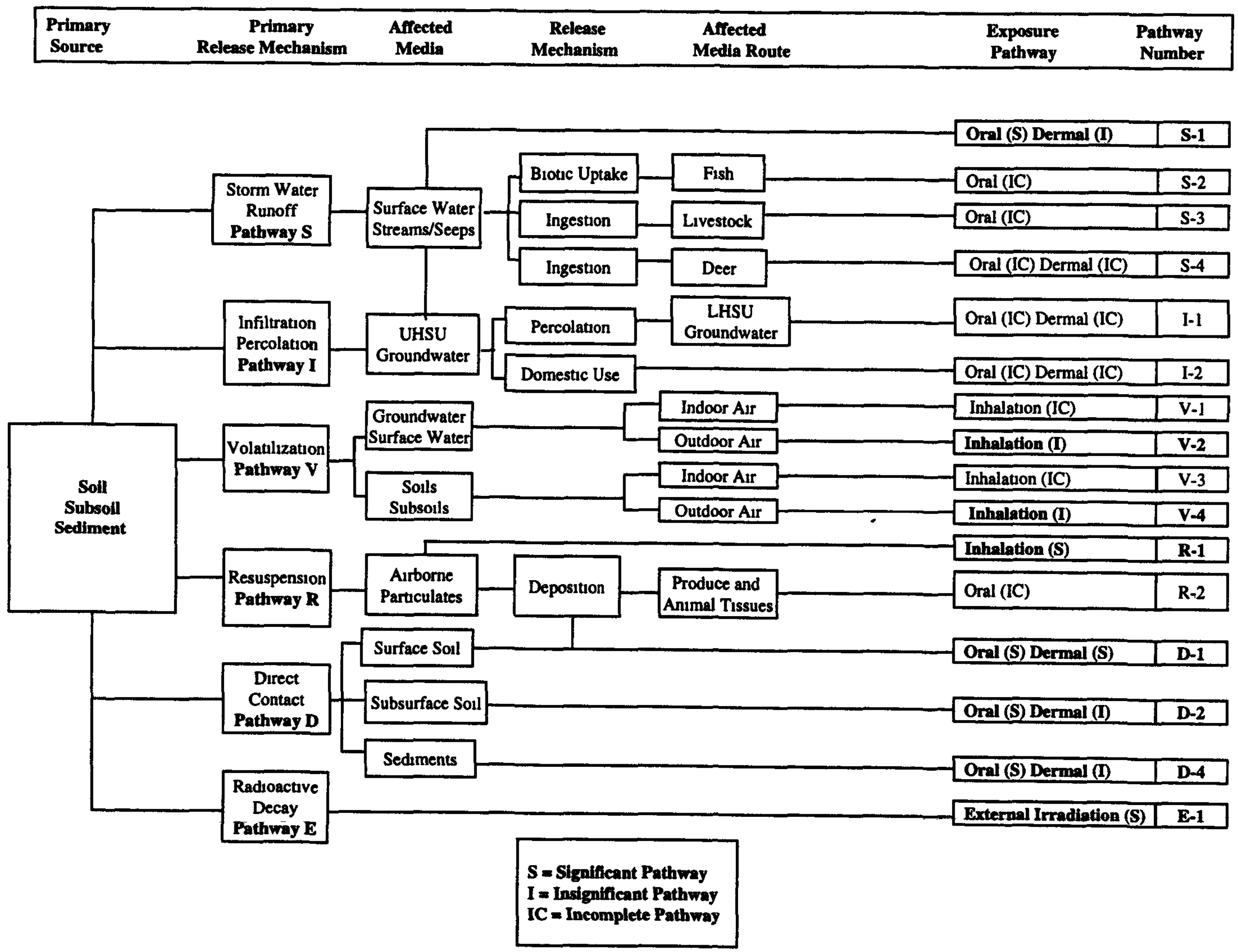

Figure 3.1 WRW Site Conceptual Model

3.3 EXPOSURE SCENARIOS

The WRW exposure scenario was used in this risk assessment based on identification of likely long-term on-site land use, potential receptors, and the site conceptual model The site conceptual model (Figure 3 1) includes surface exposure via inhalation, ingestion, dermal contact, external radiation exposure, and exposure to ingestion of potentially contaminated surface water resulting from sediment and groundwater transport Off-site receptors were not evaluated in this risk assessment, but will be addressed in the CRA that will evaluate potential cumulative impacts to off-site receptors from all sources of contamination Specific scenario parameters used in this risk assessment are listed in Tables 3 1 and 3 2 Exposure parameters and assumptions are similar to the RSALs Task 3 Report with the exceptions discussed below (DOE 2002a)

The WRW scenario has no indoor exposure component This is consistent with statements by DOE and the U S Fish and Wildlife Service that no office buildings will be built in contaminated areas It is assumed that workers will spend 50 percent of their on-site 8-hour work day outdoors The other 50 percent of their work day will be spent in an office in an uncontaminated area Select WRW exposure variables are described as follows

Table 3.1 Surface Soil Exposure Factors for the Wildlife Refuge Worker

Exposure Variable	Acronym	Units	Point Estimate	Information Sources
Body weight	BW	kg	70	EPA default
Exposure time	ET	hr/day	4	RSALS Task 3 Report
Exposure time fraction, outdoors	ETo	unitless	1	No building
Area use factor	AUF	unitless	1	AOC area/EU area
Exposure frequency	EF	day/yr	230	EPA default of 250 days minus 20 days for subsurface exposure
Exposure duration	ED	yr	18 7	RSALs Task 3 Report
Events per day	EV	ev/d	1	Unit correction
Carcinogenic averaging time	ATc	day	25550	70 yr x 365 days/yr
Noncarcinogenic averaging time	ATn	day	6826	18 7 yr x 365 days/yr
Hourly inhalation rate	IR_h	m^3/hr	1 3	RSALs Task 3 Report
Mass loading	ML	kg/m^3	2 12E-08	50th percentile of RSALS distribution
Site-specific PEF based on ML	PEF	m^3/kg	47169811	1/ML
Soil ingestion rate	IR_s	mg/day	100	EPA default
Dermal adherence factor	AF_d	mg/cm^2	0 1	EPA 2001
Surface area of exposed skin - soil	SA_s	cm^2	4260	EPA 1997b
Area weighting factor-pond liners	AWFpl	unitless	0 2	SEP area/AOC area
Area weighting factor-soils	AWFs	unitless	0 8	Surface soil area/AOC area

Exposure Variable	Acronym	Units	Point Estimate	Information Sources
Gamma exposure factor (annual)	EF/365	unitless	0 63	EF/365
Gamma exposure factor (daily)	ET/24	unitless	0 17	ET/24 per RAGS Part B (EPA 1993)
Gamma shielding factor	(1 - Se)	unitless	1	EPA 1993

Table 3.2 Subsurface Soil Exposure Factors for the Wildlife Refuge Worker

Body weight	BW	kg	70	EPA default
Exposure time outdoors	ET	hr/day	4	RSALS Task 3 Report
Area Use Factor	AUF	unitless	1	AOC area/EU area
Exposure frequency	EF	day/yr	20	WRWs in Rocky Mountain Arsenal (RMA) survey, 1990
Exposure duration	ED	yr	18 7	RSALS Task 3 Report
Events per day	EV	ev/d	1	Unit correction
Carcinogenic averaging time	ATc	day	25550	70 yr x 365 days/yr
Noncarcinogenic averaging time	ATn	day	6826	18 7 yr x 365 days/yr
Hourly inhalation rate	IR_h	m^3/hr	1 3	RSALs Task 3
Mass loading	ML	kg/m^3	2 12E-08	50th percentile of RSAL distribution
Site-specific PEF based on ML	PEF	m^3/kg	47169811	1/ML
Soil ingestion rate	IR_s	mg/day	100	EPA default
Dermal adherence factor	AF_d	mg/cm^2	0 1	EPA 2001
Surface area of exposed skin - soil	SA_s	cm^2	4260	EPA 1997b
Gamma exposure factor (annual)	EF/365	unitless	0 05	EF/365
Gamma exposure factor (daily)	ET/24	unitless	0 17	ET/24 per RAGS Part B (EPA 1993)
Gamma shielding factor	(1 - Se)	unitless	1	EPA, 1993

- By agreement with the regulatory agencies, an area use factor (AUF) of 1 was assumed for the WRW in the SEP risk assessment The AUF is the ratio of the AOC to the entire anticipated EU that the WRW will actually use The area for the AOC is 33 3 acres EUs could be as large as 400 to 500 acres The risk assessment therefore assumes that the WRW will be present within the 33 3-acre AOC 100 percent of the time This assumption is conservative because the WRW is expected to use a much larger on-site area The AUF can significantly affect risk estimates Alternative risk calculations using more realistic AUF assumptions are presented in Section 5 3 Risk managers can use the uncertainty discussion in the decision-making process
- A central tendency 50th percentile mass loading (ML) value was used to estimate risk via the inhalation exposure pathway over the 18 7-year exposure period The RSALs Task 3 calculations used an upper 95th percentile value The site average annual ML from CDPHE monitoring data is 11 8 micrograms per cubic meter ($\mu g/m^3$) The 95th percentile value taken from the RSALs Task 3 is 67 $\mu g/m^3$ This estimate was derived from an empirical distribution assuming on-site prairie fires and is a factor of six higher than annual averages based on 6 years of monitoring data Therefore, the 50th percentile value of 21 2 $\mu g/m^3$ from the Task 3

distribution was chosen for this risk assessment Alternative risk estimates are presented in Section 5 3, including all three ML estimates for use by risk managers

- The ML factor for surface soil was used for subsurface exposures because the WRW is expected to have small excavations such as posthole digging or trail improvement This is a reasonable estimate of the ML for subsurface soil exposure The area weighting factor (AWF) was based on the surficial area of the AOC covered by the liners and surface soil The WRWs' exposure to the liner materials and surface soils will be proportional to the area covered by each medium Use of the AWF allows the apportionment of risk between the soil and liners This information will be helpful to the risk managers in making informed decisions regarding possible remediation If the AWF is not used, it must be assumed that the WRWs will spend 100 percent of their time on the soil and 100 percent on the liners, which is not possible. The area of the AOC is 33 3 acres, and the areas of the surface soil and liners are 27 2 and 6 1 acres, respectively The AWF for surface soil is therefore 27 2/33 3 = 0 817, and the AWF for the liner is 6 1/33 3 = 0 183 These values were rounded to 0 8 and 0 2, respectively, for the risk assessment (Table 3 1)
- The value for the daily gamma-exposure time factor, often abbreviated as Te_d, was calculated as exposure time (ET)/24, based on EPA Soil Screening guidance (EPA 2000b) In revisions to Chapter 4 of Risk Assessment Guidance for Superfund (RAGS) Part B (EPA 2001a), a weighted soil dermal adherence factor (AF_d) of 0 1 was used This was based on the upper 95% value for a groundskeeper and the geometric mean for a commercial gardener

3.4 EXPOSURE POINT CONCENTRATIONS

The exposure point concentration of a COC in a sampled medium is quantified using the 95UCL on the arithmetic mean The arithmetic mean is a statistically robust estimator, even when normality assumptions are not met (Gilbert 1987) The 95UCL on the mean is a conservative estimate of the average concentration to which people would be exposed over time in the exposure area If the maximum detected COC value is below the 95UCL, the maximum concentration is usually used as the exposure point concentration When data distributions were demonstrated to be lognormal, an arithmetic mean and 95UCL were calculated using log-transformed data When distributions were found to be neither normal nor lognormal, a non-parametric 95UCL was calculated

Guidance and literature for calculating exposure point concentrations were reviewed A Bootstrap non-parametric, probabilistic resampling methodology was adopted for this risk assessment to determine when observed data were not normally or lognormally distributed A normal Bootstrap program was used to derive all mean and variance estimates The Bootstrap method has been used to calculate concentration terms for estimating risk, as presented in EPA guidance, Calculating Exposure Point Concentrations at Hazardous Waste Sites (EPA 2002a) This non-parametric method was selected because many SEP data sets have unknown distributions In addition, lognormal distributions for radionuclides have inherent technical difficulties due to zero and negative concentrations and large variances

The commercially available statistics program S-Plus[tm] was used for all Bootstrap calculations This technique avoids difficulties associated with empirically determining the shape of the observed distribution because it has no distributional assumptions Resampling techniques provide estimates of the mean and variance for any distribution regardless of the specific shape The method is discussed in detail in Appendix D of EPA's Process for Conducting Probabilistic Risk Assessment (1999) It has been shown that Bootstrap methods " perform substantially better, sometimes orders of magnitude better, in estimating the 95UCL of the mean from positively skewed data sets " than other methods (EPA 1999) Estimates derived for this risk assessment were developed using 1,000 resampling events Use of 1,000 iterations was demonstrated to be sufficient in estimating the mean and associated variance The effect of conducting a greater number of iterations is discussed in Section 5 3

Distributions for all PCOCs were discussed in Section 2 3 5 Most surface soil PCOCs had non-parametric distributions However, most non-radiological subsurface soil distributions were lognormal All PCOCs were compared to background by using the appropriate test based on evaluation of both SEP and background distributions Following the background comparison and professional judgement screens, final COCs were selected to quantify the risk to the WRW Some COCs had lognormal distributions and UCLs were calculated based on standard lognormal statistical methods (Gilbert 1987, EPA 2002a) Statistical testing of final COC distributions showed that many are actually neither normal nor lognormal and non-parametric methods were appropriate (EPA 2002) Maximum observed detected concentrations were used as exposure point concentrations for all liner COCs due to limited sample sizes of n = 15

Exposure point concentrations for COCs in surface soil, liner materials, and subsurface soil are presented in Table 3 3 The exposure concentrations in surface soil were used to estimate WRW risks associated with soil ingestion, inhalation of particulates, external irradiation, and dermal contact Subsurface soil concentrations were used to estimate risks as a result of digging activities

All analytes detected in excess of screening PRGs in liner materials were retained as final COCs due to the limited ability to determine distributions and conduct statistical comparisons to background with a sample size of 15 However, 15 samples were determined to be adequate to support the risk assessment

Table 3.3 Exposure Point Concentrations [a]

Analyte (Distribution)	Maximum Conc. (mg/kg or pCi/g)	Mean[b] Conc. (mg/kg or pCi/g)	95UCL[c] (mg/kg)	95UCL (pCi/g)
Pond Liner Material				
Chromium (Max)	37 5	15 4	**37.5**	
Americium-241 (Max)	8 2	1 7		**8.2**
Uranium-238 (Max)	2 7	1 4	8 0	**2.7**
Uranium-235 (Max)	0 27	0 13	0 13	**0.27**
Surface Soil				
Cadmium (NP)	382	20 1	**38.1**	
Chromium (NP)	120	20 3	**24.8**	
Americum-241 (Log)	130	9 11		**34.2**
Plutonium-239/240 (Log)	56	4 19		**16.5**
Uranium-234 (NP)	63 4	4 16	0 001	**6.5**
Uranium-235 (NP)	2 3	0 19	0 13	**0.29**
Uranium-238 (NP)	27	2 73	11 3	**3.77**
Subsurface Soil				
Cadmium (Log)	547	1 1	**9.6**	
Americum-241 (NP)	6 1	0 487		**0.69**
Plutonium-239/240 (NP)	19 78	0 639		**1.20**
Uranium-234 (NP)	21	2 92	0 0006	**3.65**
Uranium-235 (NP)	0 87	0 125	0 071	**0.153**
Uranium-238 (Log)	11 46	1 4	0 99	**2.14**

a The 95UCL was used as the exposure point concentration for all COCs, except for the pond liner COCs, for which the maximum observed detection was used

b Estimates of the mean are from normal statistics for liner COCs, Bootstrap values for COCs with non-parametric distributions, and geometric means for COCs with lognormal distributions

c The 95UCL concentrations for mineral uranium were calculated from the 95UCL for the isotopes
Boldface values were used in the risk assessment
NP = non-parametric distribution
Log = Lognormal distribution

Most COCs in surface soil had non-parametric distributions and therefore these UCLs were calculated using the non-parametric Bootstrap method However, americium-241 and plutonium-239/240 both had lognormal distributions and lognormal 95UCLs were calculated using log-transformed data for these two radionuclides Upper 95% confidence limit 95UCLs of 16 5 and 34 2 pCi/g were obtained for plutonium-239/240 and americium-241, respectively Both lognormal 95UCLs were below maximum detected concentrations

Final COCs in subsurface soil included cadmium, americum-241, plutonium-239/240, uranium-234, uranium-235, and uranium-238 Cadmium and uranium-238 both exhibited lognormal distributions and log-transformed data were used to derive 95UCLs of 9 6 mg/kg and 2 1 pCi/g, respectively Both lognormal 95UCLs were well below maximum detected concentrations and were used to calculate risk estimates All other COCs in subsurface soil were radionuclides with non-parametric distributions The Bootstrap method was used to derive UCL estimates for COCs with non-parametric distributions

3.5 INTAKE CALCULATIONS

Intake is a measure of exposure expressed as the mass of a substance in contact with the exchange boundary per unit body weight per unit time (EPA 1989) Chemical intake is expressed in terms of milligrams (mg) of chemical ingested, inhaled, or dermally absorbed per kilogram of body weight per day (mg/kg-day) Intake of radionuclides is expressed in units of picocuries (pCi) total intake to the receptor Intakes are estimated following EPA RAGS (1989) and are based on reasonable estimates of body weight, inhalation volume, ingestion rates, soil matrix effects, frequency and duration of exposure, and estimated contaminant concentrations Exposure factors are presented in Tables 3 1 and 3 2 for workers exposed to surface and subsurface soil, respectively

The general equation for calculating chemical intake, in terms of mg/kg-day, is

$$\text{Intake} = \frac{(\text{Chemical Concentration})(\text{Contact Rate})(\text{Exposure Frequency})(\text{Exposure Duration})}{(\text{Body Weight})(\text{Averaging Time})} \quad \text{(Equation 3 1)}$$

With units of

mg/kg-day = (mg/volume or mass)(volume or mass/day)(day/year)(year)(kg)(day)

Intake of radionuclides was calculated using equations similar to those for calculating intake of chemicals Intake of radionuclides by either ingestion or inhalation is a function of radionuclide concentration, intake rate or the amount of potentially contaminated medium contacted per unit time or event, and exposure frequency and duration However, for radionuclides, averaging time and body weight are excluded from intake equations

Table 3 4 presents intake equations for each pathway evaluated in the risk assessment The equations are based on standard EPA guidance Tables 3 5 and 3 6 present the chemical intakes for all COCs, media, and exposure pathways

Table 3.4 Intake Equations for the WRW

[redacted]

Inhalation Risk = CSs x IR_h x ET x ETo x EF x ED x AWF x AUF x (1/PEF) x 1000 g/kg x SFi

Ingestion Risk = CSs x IR_s x EF x ED x AWF x AUF x 0 001 g/mg x SFo

External Radiation Risk = CSs x ED x EF/365 x ET/24 x AWF x AUF x SFe x (1-Se)

[redacted]

Inhalation Risk = [(CSs x IR_h x ET x ETo x EF x ED x AWF x AUF x (1/PEF))/(BW x ATc)] x SFinh

Ingestion Risk = [(CSs x IR_s x EF x ED x AWF x AUF x 0 000001 mg/kg)/(BW*ATc)] x SFo

Dermal Risk = [(CSs x EF x ED x AWF x AUF x EV x SA_s x AF_d x DAF x 0 000001 mg/kg)/(BW x ATc)] x SFo

[redacted]

Inhalation HQ = (CSs x IR_h x ET x EF x ED x ETo x AWF x AUF x (1/PEF))/(BW x ATn x RfDi)

Ingestion HQ =(CSs x IR_s x ED x EF x AWF x AUF x 0 000001 mg/kg)/(BW x ATn x RfDo)

Dermal HQ = (CSs x EF x ED x AWF x AUF x EV x SA_s x AF_d x DAF x 0 000001 mg/kg)/(BW x ATn x RfDo)

Abbreviation	Parameter	Units	Comment
CSs	Concentration in soil	mg/kg	
IR_h	Hourly inhalation rate	m3/hr	
IR_s	Soil ingestion rate	mg/day	
ET	Exposure time	hr/day	
EF	Exposure frequency	day/yr	
ED	Exposure duration	yr	
ETo	Exposure time fraction, outdoors	unitless	Set to 1
EV	Events per day	ev/d	
AWF	Area weighting factor	unitless	
AUF	Area use factor	unitless	Set to 1
EF/365	Gamma exposure factor (annual)	unitless	
ET/24	Gamma exposure factor (daily)	unitless	
PEF	Site-specific PEF based on ML	m^3/kg	
SA_s	Surface area of exposed skin - soil	cm^2	
AF_d	Dermal adherance factor	mg/cm^2-ev	
DAF	Dermal absorption fraction	unitless	
SFinh	Inhalation slope factor	b	
SFo	Oral slope factor	b	
SFe	External radiation slope factor	b	
BW	Body weight	kg	
ATc	Carcinogenic averaging time	day	
ATn	Noncarcinogenic Averaging Time	day	
RfDi	Inhalation reference dose	(mg/kg-day)	
RfDo	Inhalation reference dose	(mg/kg-day)	
ACF	Area correction factor	unitless	
(1 - Se)	Gamma shielding factor	unitless	Set to 1

a Based on the WRW scenario developed by the RSALs Working Group

b Slope factors for inorganic and organic COCs are in units of $(mg/kg\text{-}day)^{-1}$
Slope factors for radionuclide inhalation and ingestion exposures are in units of risk/pCi
Slope factors for external exposures are in units of risk/yr per pCi/g

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Table 3.5 Intakes for the WRW From Surface Soil and Liner Material

COC	Exposure Pathways				Total Intake
	Inhalation	Ingestion	Dermal	External	
Carcinogenic Intakes From Surface Soil (mg/kg-day)					
Cadmium	8 07E-09	a	a	NA	8 1E-09
Chromium	5 27E-09	a	a	NA	5 3E-09
Non-Carcinogenic Intakes from Surface Soil (mg/kg-day)					
Cadmium	3 02E-08	2 74E-05	1 17E-04	NA	1 44E-04
Chromium	1 97E-08	1 79E-05	7 62E-05	NA	9 41E-05
Uranium-234	a	7 54E-10	3 21E-09	NA	3 97E-09
Uranium-235	a	9 62E-08	4 10E-07	NA	5 06E-07
Uranium-238	a	8 11E-06	3 46E-05	NA	4 27E-05
Radiation Intakes From Surface Soil (pCi or y-pCi/g)					
Americium-241	1 30E+01	1 18E+04	NA	5 37E+01	NA
Plutonium-239/240	6 26E+00	5 68E+03	NA	2 59E+01	NA
Uranium-234	2 48E+00	2 25E+03	NA	1 03E+01	NA
Uranium-235	1 10E-01	9 94E+01	NA	4 54E-01	NA
Uranium-238	1 43E+00	1 30E+03	NA	5 93E+00	NA
Carcinogenic Intakes From Pond Liner (mg/kg-day)					
Chromium	7 95E-09	a	a	NA	8 0E-09
Non-Carcinogenic Intakes From Pond Liner (mg/kg-day)					
Chromium	2 98E-08	2 70E-05	1 15E-04	NA	1 42E-04
Uranium-235	a	2 25E-08	2 23E-11	NA	2 25E-08
Uranium-238	a	1 44E-06	1 43E-09	NA	1 44E-06
Radiation Intakes From Pond Liner (pCi or y-pCi/g)					
Americium-241	7 76E-01	7 04E+02	NA	3 22E+00	NA
Uranium-235	2 56E-02	2 32E+01	NA	1 06E-01	NA
Uranium-238	2 54E-01	2 31E+02	NA	1 05E+00	NA

a No toxicity factor available for this exposure pathway

NA not applicable

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Table 3.6 Intakes for the WRW From Subsurface Soil and Liner Material

COC	Exposure Pathways				Total Intake
	Inhalation	Ingestion	Dermal	External	
Carcinogenic Intakes From Subsurface Soil (mg/kg-day)					
Cadmium	2 22E-10	a	a	NA	2 2E-10
Non-Carcinogenic Intakes From Subsurface Soil (mg/kg-day)					
Cadmium	8 31E-10	7 54E-07	3 21E-06	NA	3 97E-06
Uranium-234	a	4 57E-11	1 95E-10	NA	2 41E-10
Uranium-235	a	5 55E-09	2 36E-08	NA	2 92E-08
Uranium-238	a	7 74E-08	3 30E-07	NA	4 07E-07
Radiation Intakes From Subsurface Soil (pCi or y-pCi/g)					
Americium-241	2 85E-02	2 59E+01	NA	1 18E-01	2 6E+01
Plutonium-239/240	4 96E-02	4 50E+01	NA	2 06E-01	4 5E+01
Uranium-234	1 50E-01	1 36E+02	NA	6 23E-01	1 4E+02
Uranium-235	6 32E-03	5 73E+00	NA	2 62E-02	5 7E+00
Uranium-238	8 80E-02	7 98E+01	NA	3 65E-01	8 0E+01

a No toxicity factor available for this exposure pathway

NA Not applicable

4.0 TOXICITY ASSESSMENT

This section describes toxicity factors that were combined with estimated intakes of COCs to estimate the potential risk associated with exposure Toxicity factors used in the risk assessment are EPA-verified or provisional carcinogenic slope factors (SFs), and non-carcinogenic reference doses (RfDs) or air reference concentrations (RfCs) Toxicity factors for SEP final COCs are presented in Table 4 1 Toxicity factors for radionuclides were taken from Federal Guidance Report 13

The principal indices of toxicity for chemicals with non-carcinogenic effects are the oral RfD and inhalation RfD RfDs can be considered threshold doses or exposure levels At chemical doses or exposures below threshold values, adverse effects are not expected to occur RfDs incorporate a number of safety factors to ensure that they are health-protective for all human populations, including sensitive subgroups, such as children and the elderly

Oral and inhalation SFs are used to characterize the potency of carcinogens A SF is a dose-response factor used to relate carcinogenic response to chemical dose SFs are used to estimate the upper-bound probability of an individual developing cancer as a result of exposure to a potential carcinogen EPA policy assumes that carcinogenic responses have no threshold, and that any exposure to a carcinogen may result in some finite cancer risk at any dose, no matter how small (EPA 1989)

SFs for radionuclides are derived based on radionuclide emissions and their relative biological damage to exposed tissues, residence time of radionuclides in various body tissues, and duration of exposure Radionuclide dose is calculated as a yearly intake followed by a 50-year dose commitment period SFs for radionuclides are presented for external exposure, inhalation, and ingestion of radioactive materials Dermal exposure to radionuclides was considered to be insignificant

EPA assumes that any dose of a radionuclide has the potential to produce carcinogenic effects in a linear, no threshold model However, EPA does not recommend the evaluation of non-carcinogenic effects for radionuclides because these impacts have been shown to be insignificant compared to carcinogenic effects at most Superfund sites (EPA 1989) The only exception is uranium for which an assessment of the chemical toxicity is conducted Chemical toxicity of uranium was therefore evaluated for this risk assessment EPA has developed both internal (inhalation and ingestion) and external SFs for the carcinogenic response to radionuclide exposure (EPA 2001b)

The RfDs and SFs used in the risk assessment were obtained from the following sources

- EPA's IRIS online database (EPA 2002b),
- EPA's HEAST and supplements (EPA 1997c), and
- EPA's National Center for Environmental Assessment (NCEA) for interim and provisional values

4.1 Dermal Exposure to Chemicals

EPA recommends using oral toxicity factors, adjusted if possible by a gastrointestinal absorption fraction, to evaluate toxic effects from dermal contact with potentially contaminated media (EPA 1989, 1992b, 2001a) The oral toxicity factor relates the toxic response to an administered intake dose of contaminant, which may be only partially absorbed by the body Intake from dermal contact is estimated as an absorbed dose Therefore, EPA (2001a) suggests adjusting some oral toxicity factors by contaminant-specific gastrointestinal absorption rates, if available, to yield toxicity factors for contaminants absorbed via the dermal pathway When specific gastrointestinal absorption rates are not available, gastrointestinal absorption is assumed to be 100 percent and the unadjusted oral toxicity factor is used to assess the response to dermal absorption Adjustments were made to the oral toxicity factors for cadmium and chromium RfDs for this risk assessment by using a gut absorption of 2 5 percent multiplied by the oral RfD to estimate the dermal adjusted RfD, as shown in Table 4 1

5.0 RISK CHARACTERIZATION AND UNCERTAINTY ANALYSIS

Risk characterization was performed as the final step of the risk assessment process In this step, toxicity factors, non-carcinogenic RfDs, and carcinogenic SFs for COCs were applied, in conjunction with estimated chemical intakes, to predict potential non-carcinogenic and carcinogenic health risks to exposed receptors Spreadsheets with calculations are presented in Appendix C

5.1 RISK METHODOLOGY

The methodologies presented in this section were used to quantify both carcinogenic and non-carcinogenic risk

5.1.1 Non-Carcinogenic Risk

The potential for non-carcinogenic effects can be characterized by comparing estimated contaminant intakes from Section 3 5 with contaminant-specific RfDs from Table 4 1 The resulting ratio is the HQ, which is derived in the following manner

$$\text{Non-carcinogenic HQ} = \frac{\text{Chemical Intake (mg/kg-day)}}{\text{RfD (mg/kg-day)}} \qquad \text{(Equation 5 1)}$$

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Table 4.1. Toxicity Factors

Analyte	CAS Number	DAF[a]	Oral RfD (mg/kg-day)		Dermal Adjusted RfD[b]	Inhalation RfD (mg/kg-day)		Oral Slope Factor (mg/kg-day)$^{-1}$		Inhalation Slope Factor (mg/kg-day)$^{-1}$						External Slope Factor (risk/yr/pCi/g)	
Cadmium	7440-43-9	0 001	1 00E-03	I	2 50E-05	5 70E-05	E	--		6 30E+00	I						
Chromium[b]	7440-47-3	0 001	3 00E-03	I	7 50E-05	3 00E-05	I	--		4 10E+01	H						
								Oral/Ingestion Slope Factors (f)									
			Oral RfD (mg/kg-day)					(risk/pCi) Water Ingestion		Food Ingestion		Soil Ingestion		(risk/pCi)			
Americium-241	14596-10-2							1 04E-10	E	1 34 E-10	E	9 1E-11	R	2 78E-08	E	2 76E-08	E
Plutonium-239	15117-48-3							1 35E-10	E	1 74E-10	E	1 21E-10	R	3 33E-08	E	2 00E-10	E
Uranium-234	13966-29-5	0 001	3 00E-03	I				7 07E-11	E	9 55E-11	E	5 11E-11	R	1 14E-08	E	2 52E-10	E
Uranium-235	15117-96-1	0 001	3 00E-03	I				6 96E-11	E	9 44E-11	E	4 92E-11	R	1 01E-08	E	5 18E-07	E
Uranium-238	7440-61-1	0 001	3 00E-03	I				6 4E-11	E	8 66E-11	E	4 66E-11	R	9 35E-09	E	4 99E-11	E

Notes

a Values for dermal adsorption factor (DAF) are from EPA (2001) Values for chromium and cadmium are default values based on the value for chromium VI

b Dermal adjusted RfDs were calculated based on a 2 5 percent gut absorption

I = IRIS

E = NCEA provisional value

H = HEAST

R = RSALS PRG tables

References

EPA 1997c, 2001a, 2001b, and2002b

The RfD concept assumes that there is a level of intake (the RfD), below which it is unlikely that even sensitive individuals will experience adverse health effects over a lifetime of exposure If the average daily intake exceeds the RfD, the HQ is greater than 1 0, and the potential for non-carcinogenic effects increases (EPA 1989) An HQ in excess of 1 0 would trigger a more detailed evaluation of risk to receptors in this risk assessment It should be noted, however, that the level of concern does not increase linearly as the RfD is approached or exceeded This is because all RfDs are not assessed equally or based on the same severity of toxic effects The numeric value of the HQ is not a direct estimate of risk (EPA 1989) because it does not define a dose-response relationship Rather, it is an indicator that adverse health effects are more likely to occur as the HQ increases

HQs were summed to yield an HI for each pathway and receptor to assess exposure to multiple contaminants The assumption of additive effects reflected in the HI is most properly applied to substances that induce the same effect by the same mechanism (EPA 1989) Consequently, summing HQs for substances that were not expected to induce the same type of effect will likely overestimate potential adverse health effects The HI, therefore, provides a conservative measure of potential adverse health effects and is dependent on the quality of experimentally derived evidence

HIs from all relevant pathways were summed to obtain total HIs for a given receptor If the total HI was less than or equal to 1 0, multiple-pathway exposures for all COCs judged unlikely to result in any adverse health effects If the sum was greater than 1 0 further evaluation of exposure assumptions and toxicity is warranted to ascertain whether cumulative exposure would be likely to harm exposed receptors

5.1.2 Carcinogenic Risk

Potential carcinogenic effects can be characterized in terms of incremental probability of an individual developing cancer over a 70-year lifetime as a result of exposure to a potential carcinogen The excess lifetime cancer risk is an estimate of the increased risk of developing cancer above the background rate for the general population Excess lifetime cancer risk is estimated from the projected lifetime average daily intake and the cancer SF, which represents an estimate of the dose-response relationship Excess lifetime cancer risk is calculated by multiplying the average daily chemical intake by the cancer SF as follows

$$\text{Cancer Risk} = (\text{Average Daily Intake})(\text{SF}) \qquad \text{(Equation 5 2)}$$

With units of $(\text{mg/kg-day})(\text{mg/kg-day})^{-1}$ or $(\text{pCi})(\text{risk/pCi})$

Carcinogenic risks estimated using SFs are upper-bound estimates This means that the actual risk is likely to be less than the estimated risk (EPA 1989) RME cancer risks may be overestimated because they are calculated by multiplying 95th percentile estimates of cancer potency, 95UCLs of concentrations, and high-end estimates of several exposure parameters

Risks resulting from exposure to multiple carcinogens are assumed to be additive (EPA 1989) The total cancer risk is estimated by summing risks estimated for each COC for each pathway This is a conservative approach that results in an elevated estimate of cancer risk because 95th percentile estimates are not strictly additive (EPA 1989) This is especially true when more than several carcinogens are present

In accordance with EPA guidance (EPA 1989), radionuclide risks were calculated separately for each exposure pathway Carcinogenic risks for each pathway due to radionuclides are presented in Appendix C Chemical and radiological carcinogenic risks were summed by media to determine the overall potential human health hazard at the site, as shown in Tables 5 1 and 5 2

EPA policy must be considered in order to interpret the significance of cancer risk estimates The National Oil and Hazardous Substances Pollution Contingency Plan (EPA 1990) states that "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk of between 10^{-4} and 10^{-6}" When cumulative carcinogenic risk to an individual, based on RME exposure, does not exceed 10^{-4} and the total HI does not exceed 1 0, action is generally not warranted for protection of public health (EPA 1991) However, the specific target risk for the WRW is 1E-05 (DOE 2002b)

5.2 RISK RESULTS

The WRW receptor was evaluated for potential exposures in the SEP AOC One scenario was assessed for the WRW receptor with the liner materials on the surface Health risks and hazards were found to be low for the SEP AOC The results are presented and discussed below

5.2.1 Non-carcinogenic Hazard Index

The cumulative HI for non-carcinogenic health effects is 0 05 (Table 5 1) The surface soil dominated the results No adverse non-carcinogenic health effects are expected, even for sensitive individuals, because HIs were much less than 1 0 for all media and pathways The HQs for each COC and pathway are shown in Table 5 2 Cadmium in surface soil and chromium in the liner material were the major contributors

Table 5.1 Summary of HIs for the WRW by Media and Exposure Pathway

Medium	Inhalation	Ingestion	Dermal	Total HI
Liner Material	0 001	0 01	0 002	0 01
Surface Soil	0 001	0 04	0 006	0 04
Subsurface Soil	0 00001	0 001	0 0001	0 001
Total HI	**0.002**	**0.04**	**0.008**	**0.05**

Table 5.2 HQs and HIs by COC, Media, and Exposure Pathway

COC	Exposure Pathway			HI
	Inhalation	Ingestion	Dermal	
Pond Liners				
Chromium	0 001	0 009	0 002	0 01
Uranium-235	a	0 00002	0 00000000002	0 00002
Uranium-238	a	0 002	0 000000002	0 002
Total HI	**0.001**	**0.01**	**0.002**	**0.01**
Surface Soil				
Cadmium	0 0005	0 03	0 005	0 03
Chromium	0 0007	0 006	0 001	0 007
Uranium-234	a	0 0000003	0 000000001	0 0000003
Uranium-235	a	0 00003	0 0000001	0 00003
Uranium-238	a	0 003	0 00001	0 003
Total HI	**0.001**	**0.04**	**0.006**	**0.04**
Subsurface Soil				
Cadmium	0 00001	0 001	0 0001	0 001
Uranium-234	a	0 00000002	0 0000000001	0 00000002
Uranium-235	a	0 000002	0 00000000002	0 000002
Uranium-238	a	0 00003	0 0000000003	0 00003
Total HI	**0.00001**	**0.001**	**0.0001**	**0.001**

a No toxicity factor available

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5.2.2 Carcinogenic Risk

Excess lifetime cancer risk estimates for the WRW receptor are summarized in Table 5 3 by medium The total non-radiological carcinogenic risk was 2E-06 and the total radiological carcinogenic risk was 5E-06 The majority of both the non-radiological and radiological risks were from exposures to surface soil

Table 5 4 presents carcinogenic risks by media, pathway, and COC The total risk for chromium in the liner materials was 3E-07, well below the 1E-06 level of concern The highest radiological risk of 3E-06 was due to americium-241 in surface soil The risk levels were driven by the inhalation pathway for chromium VI and the ingestion and external radiation pathway for americium-241 in surface soil

The estimated excess lifetime risks for a WRW due to potential exposures in the SEP AOC were well below the 1E-06 level of concern Approximately 81 percent of the non-radiological risk was due to chromium in surface soil The remaining 19 percent was due to cadmium in surface soil Chromium was conservatively assessed as chromium VI, actual risks are likely lower due to the presence of chromium III

Table 5.3 Summary of WRW Carcinogenic Risks by Media and Exposure Pathway

Medium	**Exposure Pathway**			**Total Risk**
	Inhalation	**Ingestion**	**Dermal**	
	Non-Radiological Risks			
Liner	3 3E-07	a	a	3 3E-07
Surface Soil	2 7E-07	a	a	2 7E-07
Subsurface Soil	1 4E-09	a	a	1 4E-09
Total Risk				**2E-06**
	Radiological Risks			
	Inhalation	**Ingestion**	**External**	
Liner on Surface	2 4E-08	7 6E-08	1 4E-07	2 4E-07
Surface Soil	6 1E-07	1 9E-06	1 7E-06	4 3E-06
Subsurface Soil	5 0E-09	1 6E-08	1 8E-08	3 9E-08
Total Risk				**5E-06**

a No toxicity factor available

The total radiological risk to the WRW was 5E-06 Surface soil accounted for 94 percent of the radiological carcinogenic risk Americium-241, plutonium-239/240, and uranium-

235 were the major contributors to risk (see Table 5 4 and Appendix C) Americium-241 dominated all pathways, plutonium-239/240 was a significant contributor to the inhalation and ingestion pathways, and uranium-235 was significant for the external radiation pathway

Table 5.4 Summary of WRW Carcinogenic Risks by COC, Media, and Exposure Pathway

	Exposure Pathways				
COC	Inhalation	Ingestion	Dermal	External	Total Risk by COC
Pond Liner					
Chromium	3 26E-07	a	a	NA	3 26E-07
Americium-241	2 16E-08	6 41E-08	NA	8 88E-08	1 7E-07
Uranium-235	2 59E-10	1 14E-090	NA	5 49E-08	4 3E-08
Uranium-238	2 38E-09	1 07E-08	NA	5 25E-11	1 3E-08
Surface Soil					
Cadmium	5 09E-08	a	a	NA	5 1E-08
Chromium	2 16E-07	a	a	NA	2 2E-07
Americium-241	3 60E-07	1 07E-06	NA	1 48E-06	2 9E-06
Plutonium-239/240	2 08E-07	6 87E-07	NA	5 18E-09	9 0E-07
Uranium-234	2 83E-08	1 15E-07	NA	2 59E-09	1 5E-07
Uranium-235	1 11E-09	4 89E-09	NA	2 35E-07	2 4E-07
Uranium-238	1 34E-08	6 05E-08	NA	2 96E-10	7 4E-08
Subsurface Soil					
Cadmium	1 40E-09	a	a	NA	1 40E-09
Americium-241	7 94E-10	2 36E-09	NA	3 26E-09	6 4E-09
Plutonium-239/240	1 65E-09	5 45E-09	NA	4 11E-11	7 1E-09
Uranium-234	1 71E-09	6 97E-09	NA	1 57E-10	8 8E-09
Uranium-235	6 38E-11	2 82E-10	NA	1 35E-08	1 4E-08
Uranium-238	8 23E-10	3 72E-09	NA	1 82E-11	4 6E-09

a No toxicity factor available
NA not applicable

5.3 UNCERTAINTIES AND LIMITATIONS

This section discusses major uncertainties and limitations of the risk assessment and how the results and conclusions might be affected Uncertainties and limitations are inherent in the risk assessment process The level of certainty associated with the conclusions of the risk assessment are conditional upon data quality, methods used to identify COCs, estimates of chemical concentrations, assumptions made in estimating exposure conditions, conservatism of methods used to develop exposure factors, and toxicity values used to characterize risk

Conservative assumptions were made at most stages of this risk assessment to prevent underestimating potential health risk Carcinogenic risks were estimated using upper-bound SFs and conservative exposure assumptions Estimates of non-carcinogenic toxicity values (RfDs) are also conservative and may result in an overestimate of non-carcinogenic health hazards RME estimates of potential health risks associated with potential exposures at the SEP should be considered upper bounds This means that actual risks are likely less than estimated risk (EPA 1989) Although point estimates of risk are made, it should be recognized that each estimate represents a range of possible risks and is only an indicator of the actual risk

Uncertainties in the risk assessment for the SEP lie chiefly in sampling limitations, the identification of COCs, estimation of exposure point concentrations, exposure assumptions and factors, and the assessment of chemical toxicity The uncertainty factors are discussed below

5.3.1 Sampling and Identification of COCs

Samples of surface soil, subsurface soil, and pond liner materials were collected in accordance with approved work plans, and most of the chemical analytical results were validated in accordance with EPA and RFETS data validation guidelines Work plans were presented in the Final Phase I RFI/RI Work Plan for OU 4 (DOE 1992), and the chemical analytical database and data review are described in Appendix A It can be seen from Figures 2 1 through 2 5 that sampling was performed in a nonsystematic, random fashion and sampling density varied spatially The overall quality of the data was determined to be sufficient for risk assessment purposes (Section 2 0 and Attachment 1)

Identification of COCs is dependent on the quality of the sampling, analysis, and database management Data were retrieved from SWD and were considered representative of the AOC Elimination of PCOCs and selection of COCs are documented in Section 2 0

Only analytes included in ALF were evaluated for inclusion as COCs The analyte list in ALF is the official PCOC list for the site, as agreed to per Rocky Flats Cleanup Agreement (RFCA) (DOE et al 1996) Risks may have been underestimated due to the exclusion of analytes not on the ALF list However, excluded analytes were primarily essential nutrients and radionuclides or organics with no site use history These analytes are presented in Appendix A

5.3.2 Exposure Point Concentrations

The 95UCL of the mean concentration was used as a conservative estimate of exposure concentrations The 95UCL was used rather than the arithmetic mean concentration to provide an additional level of conservatism and limit uncertainties involved in estimating the true mean from a relatively small data set Small sample size, variability in sample results, inclusion of extreme values, and negative or zero values increase uncertainty in estimating the mean However, these uncertainties usually result in a high, rather than low, bias to the estimate

Section 2 0 and Attachment 1 present a detailed evaluation of data adequacy used to support and quantify risk calculations submitted for the SEP The evaluation included power calculations, and determination of mean, variance, and 95UCL estimates using Bootstrap resampling and geostatistical methods A spatial analysis and evaluation of the Bootstrap technique were also provided A comparison of upper 95UCLs from all statistical methods was included, and their impact on the reported risk results was evaluated The data adequacy evaluation focused on the radionuclides present in surface soil The results are summarized below and discussed in relation to the methods used in the risk assessment

Distributional testing was conducted and reported in Section 2 3 5 of this risk assessment A normal, lognormal, or non-parametric distribution was assigned to each analyte in surface soil and subsurface soil Distributions for liner data were not evaluated due to small sample size However, maximum detections were used to quantify risks and a background screen was not conducted for all liner COCs These assumptions likely over estimate the risk because chromium and uranium-238 would most likely be eliminated during the background COC screen The small sample size for liner COCs increases the uncertainty associated with final risk results, but observed risks from the liner are well below concern

In addition, several statistical methods were used to calculate 95UCLs to evaluate the uncertainty associated with this calculation and distributional assumptions Results of this analysis are presented in Attachment I, Data Adequacy Evaluation

Statıstıcal analyses ındıcated that samplıng at the SEP ıs adequate, especıally ın vıew of the low estımated rısk It ıs unlıkely that the use of eıther Bootstrap method underestımated true rısk The 95UCLs derıved from lognormal dıstrıbutıons appeared to estımate 95UCLs wıthın the observed range of detected concentratıons

5.3.3 Mass Loading Factors

There ıs uncertaınty assocıated wıth the ML factor used to estımate contamınant concentratıons ın aır A 50th percentıle estımate of 21 2 µg/m^3 developed by the RSALS Workıng Group, was used ın the rısk assessment Thıs figure ıs approxımately twıce the documented sıte average from monıtorıng data of 11 8 µg/m^3 The 95th percentıle value ıs approprıate for ALs used for screenıng, but ıs conservatıve for a forward-lookıng, long-term rısk assessment The effect of usıng multıple hıgh-end factors ın a rısk assessment quıckly leads to unrealıstıcally hıgh estımates of rısk EPA guıdance (1989) recommends usıng a balance of hıgh-end and central tendency estımates to avoıd thıs problem The effect of the three ML factors on ınhalatıon rısk ıs shown ın Table 5 5

Table 5.5 Effect of Using Different Mass Loading Factors on Inhalation Risk

Medium	ML = 11.8 µg/m^3 Inhalation	ML = 21.2 µg/m^3 Inhalation	ML = 67 µg/m^3 Inhalation
Non-radiological Risk			
Surface Soıl	1 5E-07	2 7E-07	8 4E-07
Lıner Materıal	1 8E-07	3 3E-07	1 0E-06
Subsurface Soıl	7 8E-10	1 4E-09	4 4E-09
Total Risk	**3E-07**	**6E-07**	**2E-06**
Radiological Risk			
Surface Soıl	3 4E-07	6 1E-07	1 9E-06
Lıner Materıal	1 3-08	2 4E-08	7 7-08
Subsurface Soıl	2 8E-09	5 0E-09	1 6E-08
Total Risk	**4E-07**	**6E-07**	**2E-06**

The effect on total ınhalatıon rısk of adjustıng the ML factor from the Sıte monıtorıng average to the RSALS 50th percentıle and then to the RSALs 90th percentıle ıs almost one order of magnıtude Uncertaıntıes assocıated wıth exposure poınt concentratıons and the ML factor are therefore lıkely to result ın an overestımate of rısks

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5.3.4 Area Use and Gamma Shielding Factors

The AUF is calculated as the ratio of the AOC to the minimum anticipated size of the EU for the WRW The AUF can be used to normalize exposure based on area The area of the AOC is 33 3 acres It was agreed with the regulatory agencies to use an AUF of 1 for the risk assessment This means that the hypothetical WRW will spend 4 hours a day, 5 days a week for 18 7 years in the AOC This is a conservative assumption that a WRW will actually spend 20 hours a week for 18 7 years on such a small portion of the total area of the Site Therefore, risks have been calculated for the conservative assumption of a 0 25 AUF to aid in the risk managers' decision-making process as shown in Table 5 6

Table 5.6 Effects of the Area Use Factor (AUF) and Gamma-Shielding Factor (1-Se) on Total Risk

		Non-Radiological Risk		
Surface Soil	2 7E-07	2 7E-07	6 7E-08	6 7E-08
Liner	3 3E-07	3 3E-07	8 2E-08	8 2E-08
Subsurface Soil	1 4E-09	1 4E-09	3 5E-10	3 5E-10
Total Risk	**6E-07**	**6E-07**	**1E-07**	**1E-07**
		Radiological Risk		
Surface Soil	4 3E-06	3 8E-06	1 1E-06	9 4E-07
Liner	2 4E-07	2 0E-07	6 1E-08	5 0E-08
Subsurface Soil	3 9E-08	3 4E-08	9 7E-09	8 4E-09
Total Risk	**5E-06**	**4E-06**	**1E-06**	**1E-06**

It was also agreed with the regulatory agencies that a gamma shielding factor would not be used to account for the effects of surface geometry and contaminant depth The assumption of no shielding, especially for low-energy gamma radiation present at RFETS is conservative and overestimates the risk The effect of incorporating a gamma shielding factor of 0 7, as calculated in Federal Guidance Report No 12 (EPA 1993) for radionuclides of similar energies as those present at RFETS, is shown in Table 5 6

Table 5 6 demonstrates that the effect of the AUF was greater than that of the gamma shielding factor The AUF has a greater influence because it affects all pathways, whereas the gamma shielding factor only affects the external radiation pathway Using the 0 25 AUF instead of the very conservative AUF of 1, reduced the estimated radiological risk from 5E-06 to 1E-06 and the non-radiological risk from 6E-06 to 1E-07

5.3.5 Bootstrap Iterations

The SEP risk assessment used 1,000 iterations of the Bootstrap program to derive estimates of the mean and variance associated with those COCs with non-parametric distributions Table 5 7 presents the estimates of the mean and variance using a higher number of iterations to evaluate the adequacy of using 1,000 iterations

Table 5.7 Estimated Averages, Variances, and Percent Errors as a Function of the Number of Bootstrap Iterations

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1,000	8 69	70,000	264 6	2 87	0 01085	1 08
2,000	8 64	140,000	374 2	2 85	0 00762	0 76
10,000	8 70	690,000	830 7	2 87	0 00346	0 35

S D = Standard deviation
SEM = Standard error of the mean

5.3.6 Toxicity Assessment

Toxicity values (RfDs and cancer SFs) derived by EPA are conservative, upper-bound estimates of potential toxicity or carcinogenicity of chemicals and central tendency estimates for radionuclides They were designed to be conservative and their use in risk assessment tends to result in conservative estimates of potential risk Only analytes in the ALF were assessed for this risk assessment The ALF represents the master list of potential chemicals of concern designated by CDPHE, EPA, and DOE in the 1996 RFCA (DOE et al 1996) However, analytes not on the list may contribute to risk These contributions were not assessed quantitatively (Section 2 3 7) In addition, some PCOCs do not have EPA-established toxicity factors Therefore, they cannot be evaluated in a quantitative risk assessment Analytes that were not assessed in the risk assessment could increase risk, but the increase is expected to be minimal Most omitted analytes were essential nutrients, tentatively identified compounds, or analytes with no known historical use at the site

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6.0 SUMMARY AND CONCLUSIONS

Estimated WRW risks resulting from exposure to COCs present in SEP media have been quantified Exposure media includes pond liner materials, surface soil, and subsurface soil Selected COCs were metals and radionuclides in liner material and soil that had concentrations above PRGs and statistically greater than background Radionuclides in surface soil were the largest contributors to risks Hazard and risk estimates are shown in Tables 5 1 through 5 4 and below

- Non-carcinogenic risks were dominated by ingestion of cadmium and chromium in surface soils A total HI for surface soils from all pathways was 0 04 The total HI due to liner materials was a factor of 4 below surface soil at 0 01 followed by subsurface soil at 0 001
- Non-carcinogenic risks for inhalation and dermal contact were well below ingestion with total HIs of 0 002 and 0 008, respectively
- Cumulative HIs for the WRW for all COCs and media were orders of magnitude below 1 0
- Carcinogenic risks for non-radiological COCs (cadmium and chromium) were well below the target risk for the WRW of 1E-05 Total non-radiological carcinogenic risk was 2 7E-04 for surface soil, 3 3E-07 for liner materials, and 1 4E-09 for subsurface soils All risks were well below 1E-06
- Radiological risk was dominated by exposure to surface soil radionuclides with a total risk of 4 3E-06 Total risks from exposure to liner materials and subsurface soils were 1 to 2 orders of magnitude lower at 2 4E-07 and 3 9E-08, respectively
- Radiological risks were dominated by external exposure and incidental ingestion of soils Inhalation composed 10 to 14 percent of the total risk from exposure to all media
- The total radiological risk to the WRW from all SEP media was 5E-06, which was well below the target risk of 1E-05 The total risk in surface soil was dominated by americium-241 and plutonium-239/240 Americium-241 contributed approximately 63 percent of the total risk
- Evaluation of the uncertainties associated with assumptions and parameters used in the risk assessment indicated that the estimated risks have been overestimated

7.0 REFERENCES

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APPENDIX A

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Table A.13b Solar Evaporation Ponds AOC - Summary Statistics for Detected Analytes in Liner

ALUMINUM	7429-90-5	4186 67	2420 00	6970 00	1165 42	mg/kg	15	15	100	22792 15	mg/kg	0 306
ANTIMONY	7440-36-0	4 85	2 55	5 60	0 94	mg/Kg	15	1	7	40 88	mg/kg	0 137
ARSENIC	7440-38-2	0 89	0 37	1 50	0 30	mg/Kg	15	9	60	2 22	mg/kg	0 677
BARIUM	7440-39-3	45 37	26 90	57 50	9 07	mg/kg	15	15	100	2642 62	mg/kg	0 022
BERYLLIUM	7440-41-7	0 23	0 10	0 70	0 18	mg/Kg	15	6	40	92 06	mg/kg	0 008
CADMIUM	7440-43-9	10 13	0 40	69 70	19 14	mg/kg	15	10	67	96 17	mg/kg	0 725
CALCIUM	7440-70-2	1832 80	832 00	2660 00	572 96	mg/Kg	15	15	100			
CESIUM	7440-46-2	2 06	0 43	7 70	2 58	mg/Kg	15	12	80			
CHROMIUM	7440-47-3	15 41	5 70	37 50	8 90	mg/kg	15	15	100	26 78	mg/kg	1 400
COBALT	7440-48-4	3 46	0 70	4 70	1 03	mg/Kg	15	14	93	154 56	mg/kg	0 030
COPPER	7440-50-8	12 93	2 20	24 60	6 23	mg/Kg	15	14	93	4088 00	mg/kg	0 006
CYANIDE	57-12-5	0 09	0 05	0 17	0 06	mg/kg	6	2	33	2044 00	mg/kg	0 000
IRON	7439-89-6	8061.33	5350 00	12200 00	1890 79	mg/Kg	15	15	100	30660 00	mg/kg	0.398
LEAD	7439-92-1	24 10	3 80	107 00	33 74	mg/kg	15	15	100	1000 00	mg/kg	0 107
LITHIUM	7439-93-2	8 17	3 80	13 40	3 05	mg/kg	15	15	100	2044 00	mg/kg	0 007
MAGNESIUM	7439-95-4	2087 33	1320 00	2750 00	348 15	mg/Kg	15	15	100		mg/kg	
MANGANESE	7439-96-5	123 18	91 90	162 00	20 38	mg/Kg	15	15	100	347 76	mg/kg	0 466
NICKEL	7440-02-0	11 64	7.80	16.20	3 00	mg/Kg	15	15	100	2044 00	mg/kg	0 008
POTASSIUM	7440-09-7	1878 67	1010 00	3110 00	625 66	mg/kg	15	15	100			
SELENIUM	7782-49-2	0 29	0.20	0 48	0 09	mg/kg	15	3	20	511 00	mg/kg	0 001
SODIUM	7440-23-5	674 13	135 00	1540 00	441 07	mg/Kg	15	15	100			
STRONTIUM	7440-24-6	11 45	5 40	17 60	4 18	mg/kg	15	15	100	61320 00	mg/kg	0 000
THALLIUM	7440-28-0	0 48	0 37	0 96	0 14	mg/kg	15	1	7			
TIN	7440-31-5	0 84	0 31	2 45	0 74	mg/Kg	15	12	80	61320 00	mg/kg	0 000
TITANIUM	7440-32-6	407 00	322 00	468 00	75 90	mg/kg	3	3	100			
VANADIUM	7440-62 2	29 41	16 30	39 00	7 57	mg/Kg	15	15	100	715 40	mg/kg	0 055
ZINC	7440-66-6	29 21	19 90	74 00	13.50	mg/Kg	15	15	100	30660 00	mg/kg	0 002
AMERICIUM-241	14596-10-2	1 70	0 00	8 19	2 35	pCi/g	15	15	60	7 60	pCi/g	1 077
CESIUM-134	13967-70-9	0 18	0 02	0 25	0 08	pCi/g	12	12	100			
CESIUM-137	10045-97-3	0 12	0 07	0 17	0 04	pCi/g	12	12	100			
PLUTONIUM-238	13981-16-3	0 01	0 01	0 02	0 00	pCi/g	6	6	100			
PLUTONIUM-239/240	10-12-8	0 92	0 01	3 36	1 15	pCi/g	15	15	100	11 60	pCi/g	0 290
STRONTIUM-89	14158-27-1	0.26	0 00	0 50	0 19	pCi/g	12	12	100			
STRONTIUM-90	10098-97 2	0 01	-0 10	0 20	0 09	pCi/g	12	12	100			
URANIUM-233 -234	11-08-5	1 71	0 68	4 66	0 92	pCi/g	15	15	100	30 00	pCi/g	0 155
URANIUM-235	15117-96-1	0 13	0 02	0 27	0 08	pCi/g	15	15	67	0 80	pCi/g	0 337
URANIUM 238	7440-61-1	1 36	0 52	2 68	0 61	pCi/g	15	15	100	35 10	pCi/g	0 076

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Table A.14 - Solar Evaporation Ponds AOC - Summary Statistics for Analytes Detected in Subsurface Samples Less Than 6 Feet

Aluminum	7429-90-5	12638 82	2250	39100	6909 30	mg/Kg	102	100	14762 8	mg/kg	2 64855
Arsenic	7440-38-2	4 75	0 295	15 5	3 21	mg/Kg	103	94	2.2	mg/kg	7 14246
Banum	7440-39-3	210 60	13 45	11600	1140 47	mg/Kg	102	99	1833 3	mg/kg	6 32726
Beryllium	7440-41-7	1 05	0 12	5 6	1 10	mg/Kg	102	37	66 5	mg/kg	08423
Cadmium	7440-43-9	15 59	0 1	547	67 93	mg/Kg	97	30	95 5	mg/kg	5 72912
CALCIUM	7440-70-2	38219 59	706	325000	57180 74	mg/Kg	102	100			
CHROMIUM	7440-47-3	15 83	3 8	56 9	9 85	mg/Kg	102	100	15 1	mg/kg	3 76821
Cobalt	7440-48-4	6 23	0 95	36 2	4 28	mg/Kg	102	87	93 8	mg/kg	38576
Copper	7440-50-8	11 10	1 8	46 9	7 34	mg/Kg	102	96	4088 0	mg/kg	01147
Cyanide	57-12-5	1 60	0 08	30 7	4 92	mg/kg	51	27	2044 0	mg/kg	01502
Iron	7439-89-6	12160 88	3210	31100	5307 71	mg/Kg	102	100	30660 0	mg/kg	1 01435
Lead	7439-92-1	10 23	2 1	37 2	6 76	mg/Kg	103	97	400 0	mg/kg	093
Lithium	7439-93-2	13 53	1 9	60	10 54	mg/Kg	103	98	2044 0	mg/kg	02935
MAGNESIUM	7439-95-4	2587 45	703	6460	1153 52	mg/Kg	102	100			
Manganese	7439-96-5	187 24	43 6	1220	168 80	mg/Kg	102	100	220 0	mg/kg	5 54606
Mercury	7439-97-6	0 23	0 025	10 8	1 12	mg/Kg	93	28	1484 0	mg/kg	00728
Molybdenum	7439-98-7	2 71	0 5	14 2	2 66	mg/Kg	101	18	511 0	mg/kg	02779
Nickel	7440-02-0	14 63	0 95	61 8	10 68	mg/Kg	99	86	2044 0	mg/kg	03023
Nitrate	14797-55-8	752 44	206	1600	430 90	MG/KG	9	100	163520 0	mg/kg	00978
POTASSIUM	7440-09-7	2711 38	66	21100	2789 97	mg/Kg	103	92			
Selenium	7782-49-2	0 45	0 09	3 15	0 63	mg/Kg	95	11	511 0	mg/kg	00616
SILICON	7440-21-3	2607 95	360	14000	2817 25	mg/Kg	55	98			
Silver	7440-22-4	0 96	0.205	5 2	0 63	mg/Kg	100	12	511 0	mg/kg	01018
SODIUM	7440-23-5	1466 01	100 5	10200	1864 89	mg/Kg	102	61			
Strontium	7440-24-6	72.22	7 9	354	68 56	mg/Kg	102	86	61320 0	mg/kg	00577
SULFIDE	18496-25-8	5 50	1	18 6	3 90	mg/kg	61	8			
THALLIUM	7440-28-0	0 28	0 024	1 25	0 26	mg/Kg	98	4			
Tin	7440-31-5	13 59	1 1	62 8	12 41	mg/Kg	101	23	61320 0	mg/kg	00102
Titanium	7440-32-6	258 14	118	464	139 78	MG/KG	7	100			
Vanadium	7440-62-2	30 22	8 2	82 2	15 92	mg/Kg	102	100	715 4	mg/kg	1149
Zinc	7440-66-6	29 80	7 2	168	21 51	mg/Kg	102	100	30660 0	mg/kg	00548
1 1,1-TCA	71-55-6	12.54	2 5	360	53 69	ug/Kg	79	1	5298325 7	ug/kg	00007
1,1,2,2-Tetrachloroethane	79-34-5	27 08	2 5	1000	123 39	ug/Kg	81	2	7517 1	ug/kg	13303
1,2,3-TRIMETHYLBENZENE	526-73-8	700 00	700	700		ug/Kg	1	100			
1,2,4-Trichlorobenzene	120-82-1	237 67	42	405	98 74	ug/Kg	27	4	864409 5	ug/kg	00047
1-octanol	111-87-5	600 00	600	600		ug/Kg	1	100			
2,4-DNT	121-14-2	237 70	43	405	98 66	ug/Kg	27	4	5626 0	ug/kg	07199
2-Butanone	78-93-3	7 31	2	29	5 99	ug/Kg	26	8	12999759 4	ug/kg	
2-Methylnaphthalene	91-57-6	215 11	35	950	166 68	ug/Kg	27	33	2044000 0	ug/kg	00046
2-PENTANONE, 4-HYDROXY-4-METHYL	123-42-2	77142 86	10000	100000	36839 42	ug/Kg	7	86			
Acenapthene	83-32-9	211 37	25	395	100 72	ug/Kg	27	11	4082746 9	ug/kg	0001
Acetone	67-64-1	40 36	1	800	123 81	ug/Kg	67	42	10220000 0	ug/kg	00008
Benzo(a)pyrene	50-32-8	237 65	34	405	98 31	ug/Kg	26	4	348 9	ug/kg	1 1609
Bis(2-ethylhexyl)phthalate	117-81-7	144 41	38	430	84 49	ug/Kg	27	48	196305 7	ug/kg	00219
Butyl benzylphthalate	85-68-7	159 19	23	375	87 11	ug/Kg	27	26	14746410 8	ug/kg	00003
Chrysene	218-01-9	224 19	43	405	98 51	ug/Kg	27	7	348343 8	ug/kg	00116
DI-n-BUTYL PHTHALATE	84-74-2	136 22	27	330	79 47	ug/Kg	27	41	7373205 4	ug/kg	00004
Di-n-octylphthalate	117-84-0	243 33	45	405	99 35	ug/Kg	27	4	1474641 1	ug/kg	00027
Diethyl phthalate	84-66-2	237 50	20	405	100 05	ug/Kg	26	8	58985643 2	ug/kg	00001
ETHYL ACETATE	141-78-6	1000 00	1000	1000		ug/Kg	1	100			
Fluoranthene	206-44-0	236 81	59	405	95 70	ug/Kg	27	4	2721831 2	ug/kg	00015
Fluorene	86-73-7	222 85	21	395	97 80	ug/Kg	27	7	4082746 9	ug/kg	0001
Lauric Diathanolamide	120-40-1	5125 00	1000	8000	2031 01	ug/Kg	8	100			
Methylene chloride	75-09-2	22 44	1	540	85 04	ug/Kg	80	46	186995 0	ug/kg	00289
MYRISTIC ACID	544-63-8	900 00	900	900		ug/Kg	1	100			
n-DODECANE	112-40-3	1260 00	300	2000	733 48	ug/Kg	5	80			
n-HEXADECANE	544-76-3	700 00	400	1000	424 26	ug/Kg	2	100			
n-Nitrosodiphenylamine	86-30-6	237 11	67	405	95 14	ug/Kg	27	4	780748 7	ug/kg	00052
n-TETRADECANE	629-59-4	2750 00	2000	3000	500 00	ug/Kg	4	75			

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Table A.14 - Solar Evaporation Ponds AOC - Summary Statistics for Analytes Detected in Subsurface Samples Less Than 6 Feet

n-UNDECANE	1120-21-4	1666 67	1000	2000	577 35	ug/Kg	3	100			
Naphthalene	91-20-3	206 30	59	395	86 81	ug/Kg	27	19	199085 5	ug/kg	00198
Octametylcyclotetrasiloxane	556-67-2	1566 67	400	2000	697 61	ug/Kg	6	83			
PALMITIC ACID	57-10-3	290 00	290	290		ug/Kg	1	100			
PENTADECANE	629-62-9	1350 00	300	2000	747 66	ug/Kg	6	83			
PHENANTHRENE	85-01-8	210 74	25	395	98 13	ug/Kg	27	11			
Phenol	108-95-2	243 85	59	405	98 31	ug/Kg	27	4	61320000 0	ug/kg	00001
Pyrene	129-00-0	202 26	17	405	105 06	ug/Kg	27	15	2211961 6	ug/kg	00018
sec-Octylbromide	557-35-7	2000 00	2000	2000		ug/Kg	1	100			
TCE	79-01-6	12 53	2 5	360	53 69	ug/Kg	79	1	1258 7	ug/kg	286
Tetrachloroethene	127-18-4	12 56	2	360	53 69	ug/Kg	79	1	55126 4	ug/kg	00653
Toluene	108-88-3	121.54	2	1200	203 78	ug/Kg	79	73	1965581 8	ug/kg	00061
TRIDECANE	629-50-5	4000 00	4000	4000		ug/Kg	1	100			
UNDECANE, 2 6-DIMETHYL-	17301-23-4	1000 00	1000	1000		ug/Kg	1	100			
Americium-241	14596-10-2	0 48	-0 04	6 1	0 98	pCi/g	95	86	2 9	pCi/g	2 09265
CESIUM-134	13967-70-9	0 04	-0 0396	0 15	0 05	pCi/g	61	34			
CESIUM-137	10045-97-3	0 03	-0 018	0 42	0 08	pCi/g	82	11			
GROSS ALPHA	12587-46-1	26 82	1 721	490	49 02	pCi/g	99	95			
GROSS BETA	12587-47-2	26 81	12 44	120	12 33	pCi/g	118	99			
Plutonium-239/240	10-12-8	0 63	-0 06	19 78	2 11	pCi/g	98	83	6 6	pCi/g	2 97464
RADIUM-226	13982-63-3	1 57	0 48	9 28	1 66	pCi/g	73	96			
RADIUM-228	15262-20-1	1.53	0 6438	3 9	0 58	pCi/g	77	95			
STRONTIUM-89,90	11-10-9	0 18	-0 6	0 74	0 26	pCi/g	88	69			
STRONTIUM-90	10098-97-2	0 14	-0 5	2 6	0 86	pCi/g	11	9			
TRITIUM	10028-17-8	0 81	0 58	3	0 57	pCi/g	18	72			
Uranium-234	11-08-5	2 92	0	21	4 01	pCi/g	118	99	17 4	pCi/g	1.20725
Uranium-235	15117-96-1	0 12	0	0 87	0 15	pCi/g	99	72	0 2	pCi/g	3 85602
Uranium-238	7440-61-1	1 95	0 1	11 46	2 13	pCi/g	118	97	1 0	pCi/g	11 08825

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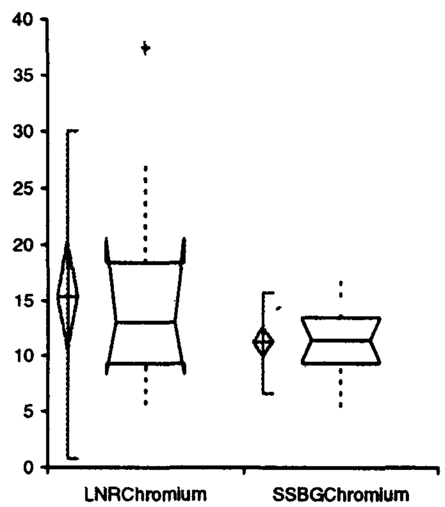
analysed with Analyse-it + General 1 63

Table A.44 **Comparative Descriptives**

Location LNRChromium, SSBGChromium

Date 10 December 2002



Location	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
LNRChromium	15	15 407	8 8955	2 2968	10 480 to 20 333	13 000	9 150	8 400 to 20 600
SSBGChromium	20	11 240	2 7799	0 6216	9 939 to 12 541	11 400	4 075	9 500 to 13 300

80

analysed with Analyse it + General 1 63

Table A 45 **Mann-Whitney Test**

Location LNRChromium ≥ SSBGChromium

Date 10 December 2002

n 35

Location	n	Rank sum	Mean rank	U
LNRChromium	15	306 5	20 43	113 5
SSBGChromium	20	323 5	16 18	186 5

Difference between medians 2 100
95 2% CI -0 600 to +∞ (normal approximation)

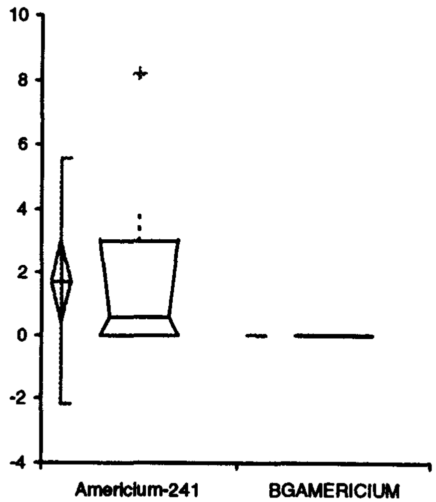
Mann-Whitney U statistic 113 5
1-tailed p 0 1118 (normal approximation corrected for ties)

82

analysed with Analyse it + General 1 63

Table A.46 **Comparative Descriptives**
Liner Background Comparison
Location Americium-241, BGAMERICIUM

Date 10 December 2002



Location	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Americium-241	15	1 705	2 3516	0 6072	0 402 to 3 007	0 580	3 002	0 005 to 3 063
BGAMERICIUM	50	0 010	0 0057	0 0008	0 009 to 0 012	0 009	0 007	0 008 to 0 012

analysed with Analyse it + General 1 63

Table A.47 **Mann-Whitney Test**

Liner Background Comparison

Location Americium-241 ≥ BGAMERICIUM

Date 10 December 2002

n 65

Location	n	Rank sum	Mean rank	U
Americium-241	15	612 0	40 80	258 0
BGAMERICIUM	50	1533 0	30 66	492 0

Difference between medians 0 565

95 1% CI 0 001 to +∞ (normal approximation)

Mann-Whitney U statistic 258

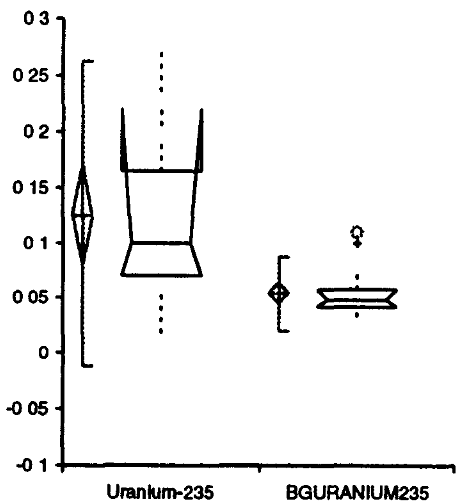
1-tailed p 0 0339 (normal approximation corrected for ties)

84

analysed with Analyse it + General 1 63

Table A.48 **Comparative Descriptives**
Liner Background Comparison
Location Uranium-235, BGURANIUM235

Date 10 December 2002



Location	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Uranium-235	15	0 125	0 0835	0 0216	0 079 to 0 171	0 100	0 095	0 070 to 0 220
BGURANIUM235	20	0 054	0 0205	0 0046	0 044 to 0 063	0 048	0 016	0 042 to 0 056

analysed with Analyse-it + General 1 63

Table A 49 | **Mann-Whitney Test**

Liner Background Comparison

Location Uranium-235 ≥ BGURANIUM235

Date 10 December 2002

n 35

Location	n	Rank sum	Mean rank	U
Uranium-235	15	373 0	24 87	47 0
BGURANIUM235	20	257 0	12 85	253 0

Difference between medians 0 048

95 2% CI 0 027 to +∞ (normal approximation)

Mann-Whitney U statistic 47

1-tailed p 0 0003 (normal approximation corrected for ties)

85

Independent Samples t-test

Liner Background Comparison
Location: lnU235 v BGlnU235

[illegible] December 2002

n	35

Location	**n**	**Mean**	**SD**	**SE**
lnU235	15	-2 298	0 725	0 1872
BGlnU235	20	-2 977	0 323	0 0722

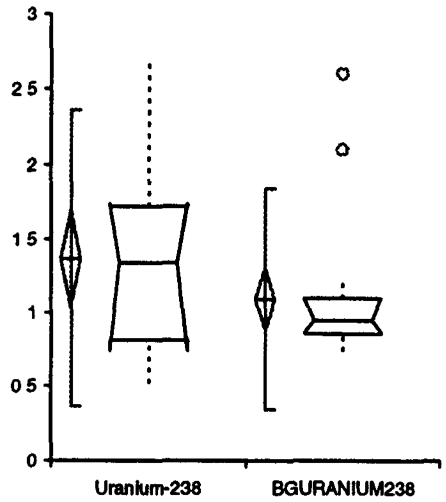
Difference between means	0 679
95% CI	0 371 to +∞

t statistic	3 74
1-tailed p	0 0004

analysed with Analyse-it + General 1 63

Table A.51 **Comparative Descriptives**
Liner Background Comparison
Location Uranium-238, BGURANIUM238

Date 10 December 2002



Location	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
Uranium-238	15	1 362	0 6082	0 1570	1 025 to 1 699	1 340	0 900	0 740 to 1 740
BGURANIUM238	20	1 090	0 4556	0 1019	0 876 to 1 303	0 950	0.240	0 870 to 1 100

analysed with Analyse it + General 1 63

Table A 52 **Mann-Whitney Test**

Liner Background Comparison

Location Uranium-238 ≥ BGURANIUM238

Date 10 December 2002

n	35

Location	n	Rank sum	Mean rank	U
Uranium-238	15	309 0	20 60	111 0
BGURANIUM238	20	321 0	16 05	189 0

Difference between medians	0 325	
95 2% CI	-0 080 to +∞	(normal approximation)

Mann-Whitney U statistic	111	
1-tailed p	0 0966	(normal approximation corrected for ties)

Table A.80 SEP Analytes in Liner Material With No PRGs in ALF

Inorganics (mg/kg)						
Calcium	7440-70-2	1,833	832	2,660	15	100
Cesium	7440-46-2	2 06	0 43	7 70	15	80
Magnesium	7439-95-4	2,087	1,320	2,750	15	100
Potassium	7440-09-7	1,879	1,010	3,110	15	100
Sodium	7440-23-5	674	135	1,540	15	100
Thallium	7440-28-0	0 48	0 37	0 96	15	7
Titanium	7440-32-6	407	322	468	3	100
Radionuclides (pCi/g)						
Cesium-134	13967-70-9	0 18	0 02	0 25	12	100
Cesium-137	10045-97-3	0 12	0 07	0 17	12	100
Plutonium-238	13981-16-3	0 01	0 01	0 02	6	100
Strontium-89	14158-27-1	0 26	0 00	0 50	12	100
Strontium-90	10098-97-2	0 01	-0 10	0 20	12	100

Table A.81 SEP Analytes in Surface Soils With No PRGs in ALF

Analyte	CAS Number	Mean	Min	Max	Total Samples	Detection Frequency (%)
Inorganics (mg/kg)						
Calcium	7440-70-2	21691	109	248000	73	99
Cesium	7440-46-2	54 2	1 25	123 5	72	3
Magnesium	7439-95-4	2567	109	6500	73	99
Potassium	7440-09-7	2544	109	8310	73	99
Silicon	7440-21-3	3529	10 9	11300	61	98
Sodium	7440-23-5	525	46 7	3660	73	37
Thallium	7440-28-0	0 24	0 08	0 81	70	9
Titanium	7440-32-6	407	322	468	3	100
Organics (µg/kg)						
9-Octadecenoic Acid	112-80-1	740	640	840	2	100
1,3-Dioxolane	2916-31-6	320	320	320	1	100
1-Methyl Naphthalene	90-12-0	80	80	80	1	100
2,6-Di-Tert-Butyl-4-Methyl Phenol	128-37-0	205	190	220	2	100
3-Penten-2-One	625-33-2	6100	6100	6100	1	100
9,10-Anthraquinone	84-65-1	210	210	210	1	100
9-Hexadecenoic Acid	2091-29-4	2000	2000	2000	1	100
Benzo(ghi)Perylene	191-24-2	190	38	680	67	45
Carbazole	86-74-8	204	140	410	7	29
Heptane	2216-30-0	150	150	150	1	100
Hexatriacontane	630-06-8	650	650	650	2	50
N-Octacosane	630-02-4	2300	2300	2300	1	100
Nonacosane	630-03-5	1100	1100	1100	1	100
Octane	2216-34-4	190	190	190	1	100
O-Fluorophenol	367-12-4	1200	1200	1200	1	100
Palmitic Acid	57-10-3	833	260	1500	10	80
Pentadecane	629-62-9	170	170	170	1	100
Pentatriacontane	630-07-9	1800	1800	1800	1	100
Phenanthrene	85-01-8	282	37	2700	67	66
Propanoic Acid	594-61-6	1100	1100	1100	1	100
Tetratetracontane	7098-22-8	1667	1600	1700	3	67
Radionuclides (pCi/g)						
Cesium-134	13967-70-9	0 02	-0 239	0 15	55	18
Cesium-137	10045-97-3	0 15	-0 0323	0 79	67	40
Radium-226	13982-63-3	1 14	0 32	10 76	47	94
Radium-228	15262-20-1	1 77	0 49	16	51	94
Strontium-89,90	11-10-9	0 36	-0 16	1 5	63	63

Table A.82 SEP Subsurface Analytes With No PRGs in ALF

[illegible]	CAS Number	Mean	Min	Max	[illegible]	Detection [illegible]
Inorganics (mg/kg)						
Calcium	7440-70-2	38,220	706	325,000	102	100
Magnesium	7439-95-4	2,587	703	6,460	102	100
Potassium	7440-09-7	2,711	66	21,100	103	92
Silicon	7440-21-3	2,608	360	14,000	55	98
Sodium	7440-23-5	1,466	101	10,200	102	61
Sulfide	18496-25-8	5 5	1	18 6	61	8
Thallium	7440-28-0	0 28	0 024	1 25	98	4
Titanium	7440-32-6	258	118	464	7	100
Organics (ug/kg)						
1,2,3-Trimethylbenzene	526-73-8	700	700	700	1	100
1-Octanol	111-87-5	600	600	600	1	100
2-Pentanone	123-42-2	77,143	10,000	100,000	7	86
Ethyl Acetate	141-78-6	1,000	1,000	1,000	1	100
Lauric Diathanolamide	120-40-1	5,125	1,000	8,000	8	100
Myristic Acid	544-63-8	900	900	900	1	100
N-Dodecane	112-40-3	1,260	300	2,000	5	80
N-Hexadecane	544-76-3	700	400	1,000	2	100
N-Tetradecane	629-59-4	2,750	2,000	3,000	4	75
N-Undecane	1120-21-4	1,667	1,000	2,000	3	100
Octametylcylotetrasiloxane	556-67-2	1,567	400	2,000	6	83
Palmitic Acid	57-10-3	290	290	290	1	100
Pentadecane	629-62-9	1,350	300	2000	6	83
Phenanthrene	85-01-8	211	25	395	27	11
Sec-Octylbromide	557-35-7	2,000	2,000	2000	1	100
Tridecane	629-50-5	4,000	4,000	4000	1	100
Undecane	17301-23-4	1,000	1,000	1000	1	100
Radionuclides (pCi/g)						
Cesium-134	13967-70-9	0 04	-0 04	0 15	61	34
Cesium-137	10045-97-3	0 03	-0 018	0 42	82	11
Radium-226	13982-63-3	1 57	0 48	9 28	73	96
Radium-228	15262-20-1	1 53	0 644	3 9	77	95
Strontium-89,90	11-10-9	0 18	-0 6	0 74	88	69
Strontium-90	10098-97-2	0 14	-0 5	2 6	11	9
Tritium	10028-17-8	0 81	0 58	3	18	72

Table A.83 Surface Soil Background Inorganic Data												
Analyte	CAS_NO	Location	Sample Number	Start Depth	End Depth	Units	Result	Censored Result	Detection Limit	Units	Lab Qualifier	Validation Qualifier
ALUMINUM	7429-90-5	SS105994	SS00111EG	0	2	IN	17100 00	17100 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106194	SS00113EG	0	2	IN	15000 00	15000 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS105594	SS00107EG	0	2	IN	13900 00	13900 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106294	SS00114EG	0	2	IN	13400 00	13400 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106894	SS00120EG	0	2	IN	13100 00	13100 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS107294	SS00125EG	0	2	IN	12700 00	12700.00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106094	SS00112EG	0	2	IN	10800 00	10800 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS105694	SS00108EG	0	2	IN	10700 00	10700 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106994	SS00121EG	0	2	IN	10700.00	10700 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106794	SS00119EG	0	2	IN	10400 00	10400 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS107194	SS00123EG	0	2	IN	10300.00	10300 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106394	SS00115EG	0	2	IN	9020 00	9020 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106594	SS00117EG	0	2	IN	8480 00	8480 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS105894	SS00110EG	0	2	IN	8360 00	8360 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106494	SS00116EG	0	2	IN	7770 00	7770 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS106694	SS00118EG	0	2	IN	7410 00	7410 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS105794	SS00109EG	0	2	IN	7340 00	7340 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS105394	SS00105EG	0	2	IN	7070 00	7070 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS107094	SS00122EG	0	2	IN	6450 00	6450 00	40 0	mg/Kg		V
ALUMINUM	7429-90-5	SS105494	SS00106EG	0	2	IN	4050 00	4050 00	40 0	mg/Kg		V
ARSENIC	7440-38-2	SS106894	SS00120EG	0	2	IN	9 60	9 60	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS106394	SS00115EG	0	2	IN	9.20	9 20	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS106594	SS00117EG	0	2	IN	8 70	8.70	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS106494	SS00116EG	0	2	IN	8 40	8 40	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS105994	SS00111EG	0	2	IN	8 30	8.30	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS106094	SS00112EG	0	2	IN	7 40	7 40	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS106794	SS00119EG	0	2	IN	6 30	6.30	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS107194	SS00123EG	0	2	IN	6.20	6.20	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS107294	SS00125EG	0	2	IN	6.10	6.10	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS106694	SS00118EG	0	2	IN	6 00	6 00	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS105894	SS00110EG	0	2	IN	5 80	5 80	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS106194	SS00113EG	0	2	IN	5.80	5 80	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS105594	SS00107EG	0	2	IN	5 30	5 30	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS107094	SS00122EG	0	2	IN	5 00	5 00	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS106994	SS00121EG	0	2	IN	4 90	4 90	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS105794	SS00109EG	0	2	IN	4 80	4 80	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS105694	SS00108EG	0	2	IN	4 40	4 40	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS106294	SS00114EG	0	2	IN	3.90	3 90	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS105394	SS00105EG	0	2	IN	3.30	3 30	2 0	mg/Kg		V
ARSENIC	7440-38-2	SS105494	SS00106EG	0	2	IN	2 30	2 30	2 0	mg/Kg		V
CADMIUM	7440-43-9	SS105594	SS00107EG	0	2	IN	2 30	2 30	1 0	mg/Kg		V
CADMIUM	7440-43-9	SS106094	SS00112EG	0	2	IN	1 00	1 00	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS106394	SS00115EG	0	2	IN	1 00	1 00	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS106794	SS00119EG	0	2	IN	0.98	0.98	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS106894	SS00120EG	0	2	IN	0.85	0 85	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS106594	SS00117EG	0	2	IN	0.84	0 84	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS105694	SS00108EG	0	2	IN	0.77	0 77	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS105894	SS00110EG	0	2	IN	0 73	0.73	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS106494	SS00116EG	0	2	IN	0 73	0 73	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS105794	SS00109EG	0	2	IN	0.71	0 71	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS106694	SS00118EG	0	2	IN	0 71	0 71	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS107094	SS00122EG	0	2	IN	0 68	0.68	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS106994	SS00121EG	0	2	IN	0 67	0 34	1 0	mg/Kg	U	V
CADMIUM	7440-43-9	SS105994	SS00111EG	0	2	IN	0 67	0 67	1 0	mg/Kg	B	V
CADMIUM	7440-43-9	SS106294	SS00114EG	0	2	IN	0 65	0.33	1 0	mg/Kg	U	V
CADMIUM	7440-43-9	SS106194	SS00113EG	0	2	IN	0 63	0.32	1 0	mg/Kg	U	V
CADMIUM	7440-43-9	SS107194	SS00123EG	0	2	IN	0 62	0 31	1 0	mg/Kg	U	V
CADMIUM	7440-43-9	SS107294	SS00125EG	0	2	IN	0 61	0 31	1 0	mg/Kg	U	V
CADMIUM	7440-43-9	SS105394	SS00105EG	0	2	IN	0 59	0 30	1 0	mg/Kg	U	V
CADMIUM	7440-43-9	SS105494	SS00106EG	0	2	IN	0 59	0 30	1 0	mg/Kg	U	V
CHROMIUM	7440-47-3	SS105994	SS00111EG	0	2	IN	16 90	16 9	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106194	SS00113EG	0	2	IN	14.80	14 8	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS105594	SS00107EG	0	2	IN	14 10	14 1	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106294	SS00114EG	0	2	IN	13.70	13 7	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106894	SS00120EG	0	2	IN	13.50	13.5	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS107294	SS00125EG	0	2	IN	13.30	13 3	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106394	SS00115EG	0	2	IN	12 10	12 1	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS107194	SS00123EG	0	2	IN	12 10	12 1	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106094	SS00112EG	0	2	IN	11 90	11 9	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106994	SS00121EG	0	2	IN	11.50	11.5	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106794	SS00119EG	0	2	IN	11.30	11 3	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS105694	SS00108EG	0	2	IN	10 70	10 7	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106494	SS00116EG	0	2	IN	10 70	10 7	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106594	SS00117EG	0	2	IN	10.50	10 5	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS106694	SS00118EG	0	2	IN	9.50	9 5	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS105894	SS00110EG	0	2	IN	9 00	9 0	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS105394	SS00105EG	0	2	IN	8 70	8 7	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS105794	SS00109EG	0	2	IN	7 50	7 5	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS107094	SS00122EG	0	2	IN	7 50	7 5	2 0	mg/Kg		V
CHROMIUM	7440-47-3	SS105494	SS00106EG	0	2	IN	5 50	5 5	2 0	mg/Kg		V
MANGANESE	7439-96-5	SS106994	SS00121EG	0	2	IN	357	357 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS106094	SS00112EG	0	2	IN	330	330 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS107194	SS00123EG	0	2	IN	313	313.00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS105994	SS00111EG	0	2	IN	302	302 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS106894	SS00120EG	0	2	IN	294	294 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS106394	SS00115EG	0	2	IN	288	288 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS105394	SS00105EG	0	2	IN	273	273.00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS107294	SS00125EG	0	2	IN	271	271 00	3.0	mg/Kg		V
MANGANESE	7439-96-5	SS106594	SS00117EG	0	2	IN	231	231 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS107094	SS00122EG	0	2	IN	229	229 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS106494	SS00116EG	0	2	IN	228	228.00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS106194	SS00113EG	0	2	IN	214	214 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS106694	SS00118EG	0	2	IN	212	212 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS105894	SS00110EG	0	2	IN	205	205 00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS106794	SS00119EG	0	2	IN	196	196.00	3 0	mg/Kg		V
MANGANESE	7439-96-5	SS105594	SS00107EG	0	2	IN	190	190 00	3.0	mg/Kg		V
MANGANESE	7439-96-5	SS106294	SS00114EG	0	2	IN	176	176 00	3.0	mg/Kg		V
MANGANESE	7439-96-5	SS105694	SS00108EG	0	2	IN	163	163.00	3.0	mg/Kg		V
MANGANESE	7439-96-5	SS105494	SS00106EG	0	2	IN	141	141 00	3.0	mg/Kg		V
MANGANESE	7439-96-5	SS105794	SS00109EG	0	2	IN	129	129 00	3.0	mg/Kg		V

Table A 84 Surface Soil Background Radionuclide Data											
Analyte	CAS NO	Location	Sample Number	Start Depth	End Depth	[illegible]	Result	Detection Limit	Units	Lab Qualifier	Validation Qualifier
AMERICIUM-241	14596-10-2	SS104194	SS00091EG	0	2	IN	0.008	0.010	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS104294	SS00092EG	0	2	IN	0.019	0.010	pCi/g	J	V
AMERICIUM 241	14596-10-2	SS104394	SS00094EG	0	2	IN	0.005	0.007	pCi/g	U	V
AMERICIUM 241	14596-10-2	SS104494	SS00095EG	0	2	IN	0.012	0.006	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS104594	SS00096EG	0	2	IN	0.007	0.010	pCi/g	U	V
AMERICIUM 241	14596-10-2	SS104694	SS00097EG	0	2	IN	0.014	0.008	pCi/g	J	V
AMERICIUM 241	14596-10-2	SS104794	SS00098EG	0	2	IN	0.015	0.007	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS104894	SS00099EG	0	2	IN	0.009	0.009	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS104994	SS00100EG	0	2	IN	0.010	0.008	pCi/g	J	V
AMERICIUM 241	14596-10-2	SS105094	SS00101EG	0	2	IN	0.018	0.008	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS105194	SS00102EG	0	2	IN	0.007	0.005	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS105294	SS00104EG	0	2	IN	0.012	0.010	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS107394	SS00126EG	0	2	IN	0.025	0.010	pCi/g		V
AMERICIUM-241	14596-10-2	SS107494	SS00127EG	0	2	IN	0.015	0.008	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS107594	SS00128EG	0	2	IN	0.019	0.007	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS107694	SS00129EG	0	2	IN	0.021	0.008	pCi/g		V
AMERICIUM-241	14596-10-2	SS107794	SS00130EG	0	2	IN	0.016	0.007	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS107894	SS00131EG	0	2	IN	0.010	0.010	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS107994	SS00132EG	0	2	IN	0.007	0.007	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS108094	SS00133EG	0	2	IN	0.019	0.007	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS108194	SS00134EG	0	2	IN	0.010	0.010	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS108294	SS00135EG	0	2	IN	0.023	0.010	pCi/g		V
AMERICIUM-241	14596-10-2	SS108394	SS00136EG	0	2	IN	0.004	0.010	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS108494	SS00137EG	0	2	IN	0.015	0.005	pCi/g	J	V
AMERICIUM 241	14596-10-2	SS108594	SS00138EG	0	2	IN	0.015	0.005	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS108694	SS00139EG	0	2	IN	0.017	0.005	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS108794	SS00140EG	0	2	IN	0.010	0.008	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS108894	SS00141EG	0	2	IN	0.005	0.010	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS108994	SS00142EG	0	2	IN	0.006	0.005	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS109094	SS00143EG	0	2	IN	0.004	0.008	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS109194	SS00144EG	0	2	IN	0.009	0.010	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS109294	SS00146EG	0	2	IN	0.005	0.010	pCi/g	U	A
AMERICIUM-241	14596-10-2	SS109394	SS00147EG	0	2	IN	0.004	0.007	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS109494	SS00148EG	0	2	IN	0.007	0.010	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS109594	SS00149EG	0	2	IN	0.009	0.006	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS109694	SS00150EG	0	2	IN	0.013	0.006	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS109794	SS00151EG	0	2	IN	0.010	0.007	pCi/g	J	A
AMERICIUM-241	14596-10-2	SS109894	SS00152EG	0	2	IN	0.007	0.009	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS109994	SS00153EG	0	2	IN	0.002	0.008	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS110094	SS00154EG	0	2	IN	0.010	0.010	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS110194	SS00155EG	0	2	IN	0.006	0.007	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS110294	SS00156EG	0	2	IN	0.002	0.006	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS110394	SS00157EG	0	2	IN	0.002	0.008	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS110494	SS00158EG	0	2	IN	0.009	0.006	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS110594	SS00159EG	0	2	IN	0.001	0.010	pCi/g	U	A
AMERICIUM-241	14596-10-2	SS110694	SS00160EG	0	2	IN	0.009	0.006	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS110794	SS00161EG	0	2	IN	0.014	0.008	pCi/g	J	V
AMERICIUM-241	14596-10-2	SS110894	SS00162EG	0	2	IN	0.009	0.010	pCi/g	U	V
AMERICIUM-241	14596-10-2	SS111094	SS00164EG	0	2	IN	0.009	0.009	pCi/g	J	A
AMERICIUM-241	14596-10-2	SS111194	SS00165EG	0	2	IN	0.009	0.010	pCi/g	U	V
PLUTONIUM-239/240	10-12-8	SS108794	SS00140EG	0	2	IN	0.032	0.007	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS104194	SS00091EG	0	2	IN	0.029	0.006	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS104294	SS00092EG	0	2	IN	0.024	0.006	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS104394	SS00094EG	0	2	IN	0.025	0.009	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS104494	SS00095EG	0	2	IN	0.044	0.005	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS104594	SS00096EG	0	2	IN	0.024	0.005	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS104694	SS00097EG	0	2	IN	0.076	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS104794	SS00098EG	0	2	IN	0.050	0.007	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS104894	SS00099EG	0	2	IN	0.037	0.007	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS104994	SS00100EG	0	2	IN	0.072	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS105094	SS00101EG	0	2	IN	0.041	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS105194	SS00102EG	0	2	IN	0.034	0.009	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS105294	SS00104EG	0	2	IN	0.052	0.006	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS107394	SS00126EG	0	2	IN	0.065	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS107494	SS00127EG	0	2	IN	0.044	0.002	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS107594	SS00128EG	0	2	IN	0.046	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS107694	SS00129EG	0	2	IN	0.050	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS107794	SS00130EG	0	2	IN	0.037	0.006	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS107894	SS00131EG	0	2	IN	0.035	0.009	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS107994	SS00132EG	0	2	IN	0.025	0.006	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS108094	SS00133EG	0	2	IN	0.075	0.009	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS108194	SS00134EG	0	2	IN	0.040	0.006	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS108294	SS00135EG	0	2	IN	0.054	0.008	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS108394	SS00136EG	0	2	IN	0.026	0.010	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS108494	SS00137EG	0	2	IN	0.038	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS108594	SS00138EG	0	2	IN	0.067	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS108694	SS00139EG	0	2	IN	0.035	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS108894	SS00141EG	0	2	IN	0.023	0.007	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS108994	SS00142EG	0	2	IN	0.026	0.008	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS109094	SS00143EG	0	2	IN	0.033	0.010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS109194	SS00144EG	0	2	IN	0.029	0.009	pCi/g	J	V

Table A 84 Surface Soil Background Radionuclide Data											
Analyte	CAS_NO	Location	Sample Number	Start Depth	End Depth	Units	Result	Detection Limit	Units	Lab Qualifier	Validation Qualifier
PLUTONIUM-239/240	10-12-8	SS109294	SS00146EG	0	2	IN	0 027	0 006	pCi/g	J	V
PLUTONIUM 239/240	10-12-8	SS109394	SS00147EG	0	2	IN	0 022	0 009	pCi/g	J	V
PLUTONIUM 239/240	10-12 8	SS109494	SS00148EG	0	2	IN	0 046	0 005	pCi/g		V
PLUTONIUM 239/240	10-12 8	SS109594	SS00149EG	0	2	IN	0 031	0 007	pCi/g		V
PLUTONIUM 239/240	10-12 8	SS109694	SS00150EG	0	2	IN	0 036	0 005	pCi/g		V
PLUTONIUM 239/240	10-12 8	SS109794	SS00151EG	0	2	IN	0 033	0 010	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS109894	SS00152EG	0	2	IN	0 031	0 006	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS109994	SS00153EG	0	2	IN	0 063	0 006	pCi/g		V
PLUTONIUM-239/240	10-12 8	SS110094	SS00154EG	0	2	IN	0 021	0 010	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS110194	SS00155EG	0	2	IN	0 043	0 004	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS110294	SS00156EG	0	2	IN	0 018	0 005	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS110394	SS00157EG	0	2	IN	0 034	0 004	pCi/g		V
PLUTONIUM-239/240	10-12 8	SS110494	SS00158EG	0	2	IN	0 027	0 005	pCi/g	J	V
PLUTONIUM 239/240	10-12-8	SS110594	SS00159EG	0	2	IN	0 017	0 009	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS110694	SS00160EG	0	2	IN	0 033	0 004	pCi/g		V
PLUTONIUM 239/240	10-12-8	SS110794	SS00161EG	0	2	IN	0 055	0 007	pCi/g		V
PLUTONIUM-239/240	10-12-8	SS110894	SS00162EG	0	2	IN	0 022	0 009	pCi/g	J	V
PLUTONIUM-239/240	10-12-8	SS111094	SS00164EG	0	2	IN	0 055	0 005	pCi/g		V
PLUTONIUM-239/240	10-12 8	SS111194	SS00165EG	0	2	IN	0 030	0 007	pCi/g		V
URANIUM-233 234	11-08-5	SS105394	SS00105EG	0	2	IN	3.100	0 020	pCi/g		V
URANIUM 233 234	11-08-5	SS105494	SS00106EG	0	2	IN	2.300	0 010	pCi/g		V
URANIUM-233, 234	11-08-5	SS105594	SS00107EG	0	2	IN	0 790	0 010	pCi/g		V
URANIUM-233 234	11-08-5	SS105694	SS00108EG	0	2	IN	0.940	0 009	pCi/g		V
URANIUM 233 234	11-08-5	SS105794	SS00109EG	0	2	IN	0 730	0.010	pCi/g		V
URANIUM-233, 234	11-08-5	SS105894	SS00110EG	0	2	IN	0 960	0 009	pCi/g		V
URANIUM 233 234	11-08-5	SS105994	SS00111EG	0	2	IN	0.910	0 008	pCi/g		V
URANIUM-233 234	11-08-5	SS106094	SS00112EG	0	2	IN	1 000	0 007	pCi/g		V
URANIUM-233, 234	11-08-5	SS106194	SS00113EG	0	2	IN	0 660	0.007	pCi/g		V
URANIUM 233, 234	11-08-5	SS106294	SS00114EG	0	2	IN	1 100	0 009	pCi/g		V
URANIUM-233 234	11-08-5	SS106394	SS00115EG	0	2	IN	1 100	0 009	pCi/g		V
URANIUM-233,-234	11-08-5	SS106494	SS00116EG	0	2	IN	1 100	0 010	pCi/g		V
URANIUM-233 234	11-08-5	SS106594	SS00117EG	0	2	IN	1 100	0 010	pCi/g		V
URANIUM-233, 234	11-08-5	SS106694	SS00118EG	0	2	IN	0 940	0 009	pCi/g		V
URANIUM-233,-234	11-08-5	SS106794	SS00119EG	0	2	IN	0 810	0 010	pCi/g		V
URANIUM-233 234	11-08-5	SS106894	SS00120EG	0	2	IN	1 000	0 010	pCi/g		V
URANIUM-233 -234	11-08-5	SS106994	SS00121EG	0	2	IN	0 780	0 010	pCi/g		V
URANIUM-233,-234	11-08-5	SS107094	SS00122EG	0	2	IN	0 950	0.010	pCi/g		V
URANIUM 233, 234	11-08-5	SS107194	SS00123EG	0	2	IN	0 850	0 010	pCi/g		V
URANIUM-233 234	11-08-5	SS107294	SS00125EG	0	2	IN	0.810	0 010	pCi/g		V
URANIUM 235	15117 96-1	SS105394	SS00105EG	0	2	IN	0.110	0.006	pCi/g	J	V
URANIUM-235	15117-96-1	SS105494	SS00106EG	0	2	IN	0 100	0 007	pCi/g	J	V
URANIUM-235	15117-96-1	SS105594	SS00107EG	0	2	IN	0 040	0 005	pCi/g	J	V
URANIUM-235	15117 96-1	SS105694	SS00108EG	0	2	IN	0 058	0 004	pCi/g	J	V
URANIUM-235	15117-96-1	SS105794	SS00109EG	0	2	IN	0.044	0 004	pCi/g	J	V
URANIUM-235	15117 96-1	SS105894	SS00110EG	0	2	IN	0 046	0 004	pCi/g	J	V
URANIUM 235	15117 96-1	SS105994	SS00111EG	0	2	IN	0.041	0 004	pCi/g	J	V
URANIUM-235	15117-96-1	SS106094	SS00112EG	0	2	IN	0.049	0.003	pCi/g	J	V
URANIUM-235	15117-96-1	SS106194	SS00113EG	0	2	IN	0.034	0.003	pCi/g	J	V
URANIUM-235	15117 96-1	SS106294	SS00114EG	0	2	IN	0 064	0 004	pCi/g	J	V
URANIUM-235	15117-96-1	SS106394	SS00115EG	0	2	IN	0 055	0.004	pCi/g	J	V
URANIUM-235	15117-96-1	SS106494	SS00116EG	0	2	IN	0 052	0 009	pCi/g	J	V
URANIUM-235	15117-96-1	SS106594	SS00117EG	0	2	IN	0 077	0 004	pCi/g	J	V
URANIUM-235	15117 96-1	SS106694	SS00118EG	0	2	IN	0 056	0 004	pCi/g	J	V
URANIUM-235	15117-96-1	SS106794	SS00119EG	0	2	IN	0 038	0 008	pCi/g	J	V
URANIUM 235	15117-96-1	SS106894	SS00120EG	0	2	IN	0.052	0 007	pCi/g	J	V
URANIUM-235	15117-96-1	SS106994	SS00121EG	0	2	IN	0 043	0 007	pCi/g	J	V
URANIUM-235	15117-96-1	SS107094	SS00122EG	0	2	IN	0.042	0 008	pCi/g	J	V
URANIUM 235	15117-96-1	SS107194	SS00123EG	0	2	IN	0.042	0 006	pCi/g	J	V
URANIUM-235	15117 96-1	SS107294	SS00125EG	0	2	IN	0.033	0 009	pCi/g	J	V
URANIUM-238	7440-61 1	SS105394	SS00105EG	0	2	IN	2 600	0 010	pCi/g		V
URANIUM 238	7440-61-1	SS105494	SS00106EG	0	2	IN	2.100	0 010	pCi/g		V
URANIUM 238	7440-61 1	SS105594	SS00107EG	0	2	IN	0 800	0 008	pCi/g		V
URANIUM 238	7440-61 1	SS105694	SS00108EG	0	2	IN	0 870	0 008	pCi/g		V
URANIUM-238	7440-61 1	SS105794	SS00109EG	0	2	IN	0 810	0 008	pCi/g		V
URANIUM-238	7440-61 1	SS105894	SS00110EG	0	2	IN	1 000	0 007	pCi/g		V
URANIUM-238	7440-61 1	SS105994	SS00111EG	0	2	IN	0 900	0 007	pCi/g		V
URANIUM-238	7440-61 1	SS106094	SS00112EG	0	2	IN	0 960	0 007	pCi/g		V
URANIUM-238	7440-61 1	SS106194	SS00113EG	0	2	IN	0 740	0 006	pCi/g		V
URANIUM-238	7440-61 1	SS106294	SS00114EG	0	2	IN	1 100	0 008	pCi/g		V
URANIUM-238	7440-61 1	SS106394	SS00115EG	0	2	IN	1 100	0 008	pCi/g		V
URANIUM 238	7440-61 1	SS106494	SS00116EG	0	2	IN	1 100	0 010	pCi/g		V
URANIUM-238	7440-61 1	SS106594	SS00117EG	0	2	IN	1.200	0 009	pCi/g		V
URANIUM-238	7440-61 1	SS106694	SS00118EG	0	2	IN	1 000	0 008	pCi/g		V
URANIUM-238	7440-61 1	SS106794	SS00119EG	0	2	IN	0 890	0 009	pCi/g		V
URANIUM-238	7440-61 1	SS106894	SS00120EG	0	2	IN	1 100	0 010	pCi/g		V
URANIUM-238	7440-61 1	SS106994	SS00121EG	0	2	IN	0 830	0 010	pCi/g		V
URANIUM 238	7440-61 1	SS107094	SS00122EG	0	2	IN	0 920	0 009	pCi/g		V
URANIUM-238	7440-61 1	SS107194	SS00123EG	0	2	IN	0 920	0 009	pCi/g		V
URANIUM-238	7440-61 1	SS107294	SS00125EG	0	2	IN	0 830	0 010	pCi/g		V

Table A 85 Subsurface Soil Background Inorganc Data										
Analyte	Location	Sample	Result	Censored Result	Detection Limit	Units	Lab Qualifier	Validation Code	Geologic Unit	Flow Unit
ALUMINUM	B200589	BH05890913	7690	3845	40	MG/KG	U	V	RFA	UPPER
ALUMINUM	B200689	BH06892430	5770	5770	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B200889	BH08890608	5780	5780	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B201289	BH12890915	6600	6600	40	MG/KG	J	A	COL	UPPER
ALUMINUM	B201189	BH11890915	6950	6950	40	MG/KG	J	A	COL	UPPER
ALUMINUM	B201289	BH12890307	7110	7110	40	MG/KG	J	A	COL	UPPER
ALUMINUM	B200889	BH08891420	7170	7170	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B201289	BH12891521	7300	7300	40	MG/KG	J	A	COL	UPPER
ALUMINUM	B200989	BH09891620	7850	7850	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B200889	BH08890814	8320	8320	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B200689	BH06890410	8610	8610	47 9	MG/KG	J	A	RFA	UPPER
ALUMINUM	B200689	BH06891824	8910	8910	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B301889	BH15891521	10900	10900	40	MG/KG	J	A	COL	UPPER
ALUMINUM	B200889	BH08892022	12030	12030	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B301889	BH15890915	13100	13100	40	MG/KG	J	A	COL	UPPER
ALUMINUM	B200689	BH06891618	14100	14100	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B200889	BH08890106	16800	16800	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B200689	BH06890104	20000	20000	40	MG/KG	J	A	RFA	UPPER
ALUMINUM	B200889	BH08890003	14900	14900	40	MG/KG	E		RFA	UPPER
ALUMINUM	B200989	BH09890003	16100	16100	40	MG/KG	E		RFA	UPPER
ALUMINUM	B200789	BH07890003	19300	19300	40	MG/KG	E		RFA	UPPER
ALUMINUM	B400289	BH02890915	20400	20400	40	MG/KG	E		RFA	UPPER
ALUMINUM	B200789	BH07891824	279	279	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400489	BH04894652	2240	2240	46 2	MG/KG		A	RFA	UPPER
ALUMINUM	B400489	BH04894046	3540	3540	50 1	MG/KG		A	RFA	UPPER
ALUMINUM	B400489	BH04895254	4130	4130	46	MG/KG		A	RFA	UPPER
ALUMINUM	B301889	BH15890003	4300	4300	49 5	MG/KG			COL	UPPER
ALUMINUM	B201189	BH11892733	4850	4850	40	MG/KG		V	COL	UPPER
ALUMINUM	B201189	BH11891521	5465	5465	40	MG/KG		V	COL	UPPER
ALUMINUM	B200589	BH05891723	5510	5510	40	MG/KG		V	RFA	UPPER
ALUMINUM	B201189	BH11892127	5540	5540	40	MG/KG		V	COL	UPPER
ALUMINUM	B200589	BH05892530	5640	5640	40	MG/KG		V	RFA	UPPER
ALUMINUM	B201189	BH11890003	5860	5860	47	MG/KG			COL	UPPER
ALUMINUM	B200989	BH09891016	6025	6025	40	MG/KG		V	RFA	UPPER
ALUMINUM	B201189	BH11890309	6075	6075	40	MG/KG		V	COL	UPPER
ALUMINUM	B200789	BH07891218	6470	6470	40	MG/KG		V	RFA	UPPER
ALUMINUM	B200789	BH07892426	6680	6680	40	MG/KG		V	RFA	UPPER
ALUMINUM	B200589	BH05892325	7130	7130	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400389	BH03892733	7200	7200	40	MG/KG		V	RFA	UPPER
ALUMINUM	B200789	BH07890612	7400	7400	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400389	BH03890003	8005	8005	40	MG/KG		V	RFA	UPPER
ALUMINUM	B201589	BH14890307	8230	8230	40	MG/KG		V	COL	UPPER
ALUMINUM	B402189	BH18890003	8270	8270	40	MG/KG		V	COL	UPPER
ALUMINUM	B201489	BH13890307	8390	8390	40	MG/KG		V	COL	UPPER
ALUMINUM	B400289	BH02893642	8420	8420	40	MG/KG		V	RFA	UPPER
ALUMINUM	B200689	BH06891016	8640	8640	43 3	MG/KG			RFA	UPPER
ALUMINUM	B400489	BH04892733	8790	8790	42 3	MG/KG			RFA	UPPER
ALUMINUM	B400389	BH03894548	8880	8880	42 3	MG/KG			RFA	UPPER
ALUMINUM	B401989	BH16891519	8910	8910	40	MG/KG		V	COL	UPPER
ALUMINUM	B400389	BH03890309	8980	8980	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400489	BH04890003	9010	9010	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400389	BH03892127	9190	9190	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400389	BH03893339	9230	9230	40	MG/KG		V	RFA	UPPER
ALUMINUM	B302089	BH17890306	9770	9770	40	MG/KG		V	COL	UPPER
ALUMINUM	B201589	BH14890003	9840	9840	44 2	MG/KG			COL	UPPER
ALUMINUM	B200589	BH05890308	9900	9900	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400389	BH03891521	9920	9920	40	MG/KG		V	RFA	UPPER
ALUMINUM	B405189	BH01893844	9950	9950	40	MG/KG		V	WCS	UPPER
ALUMINUM	B400489	BH04893840	10000	10000	60 4	MG/KG		A	RFA	UPPER
ALUMINUM	B400289	BH02890003	10200	10200	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400489	BH04891521	10200	10200	40	MG/KG		V	RFA	UPPER
ALUMINUM	B405189	BH01894448	10300	10300	40	MG/KG		V	WCS	UPPER
ALUMINUM	B400489	BH04892127	10500	10500	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400489	BH04890915	10700	10700	40	MG/KG		V	RFA	UPPER
ALUMINUM	B402189	BH18890307	10800	10800	40	MG/KG		V	COL	UPPER
ALUMINUM	B400489	BH04893335	10900	10900	55 3	MG/KG		A	RFA	UPPER
ALUMINUM	B201289	BH12890003	11000	11000	48 1	MG/KG			COL	UPPER
ALUMINUM	B400289	BH02892130	11650	11650	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400389	BH03890915	11800	11800	40	MG/KG		V	RFA	UPPER
ALUMINUM	B405189	BH01891521	11900	11900	40	MG/KG		V	WCS	UPPER
ALUMINUM	B405189	BH01893036	11900	11900	40	MG/KG		V	WCS	UPPER
ALUMINUM	B405189	BH01890309	12100	12100	40	MG/KG		V	WCS	UPPER
ALUMINUM	B200989	BH09890410	12200	12200	40	MG/KG		V	RFA	UPPER
ALUMINUM	B301889	BH15890309	12300	12300	40	MG/KG		A	COL	UPPER
ALUMINUM	B200589	BH05891317	12300	12300	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400289	BH02893036	12300	12300	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400489	BH04890309	12300	12300	40	MG/KG		V	RFA	UPPER

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Table A 85 Subsurface Soil Background Inorganc Data

Analyte	Location	Sample	Result	Converted Result	Detection Limit	Units	Lab Qualifier	Validation Code	Geologic Unit	Flow Unit
ALUMINUM	B400289	BH02891521	13000	13000	44 9	MG/KG			RFA	UPPER
ALUMINUM	B405189	BH01892127	13400	13400	40	MG/KG		V	WCS	UPPER
ALUMINUM	B201489	BH13890003	13800	13800	43 2	MG/KG			COL	UPPER
ALUMINUM	B401989	BH16890915	14900	14900	40	MG/KG		V	COL	UPPER
ALUMINUM	B401989	BH16890309	16100	16100	40	MG/KG		V	COL	UPPER
ALUMINUM	B400289	BH02890309	16600	16600	40	MG/KG		V	RFA	UPPER
ALUMINUM	B201089	BH10890106	17300	17300	40	MG/KG		V	COL	UPPER
ALUMINUM	B302089	BH17890003	17800	17800	48 2	MG/KG			COL	UPPER
ALUMINUM	B400389	BH03893945	18500	18500	40	MG/KG		V	RFA	UPPER
ALUMINUM	B400489	BH04893538	19000	19000	96 8	MG/KG		A	RFA	UPPER
ALUMINUM	B405189	BH01893638	20000	20000	40	MG/KG		V	WCS	UPPER
ALUMINUM	B401989	BH16890003	20800	20800	48 4	MG/KG			COL	UPPER
ALUMINUM	B201089	BH10890003	22900	22900	40	MG/KG		V	COL	UPPER
ALUMINUM	B405189	BH01890915	23900	23900	40	MG/KG		V	WCS	UPPER
ALUMINUM	B200589	BH05890003	25800	25800	52 2	MG/KG			RFA	UPPER
ALUMINUM	B200589	BH05890003F	25800	25800	52 2	MG/KG			RFA	UPPER
ALUMINUM	B200789	BH07890306	27600	27600	40	MG/KG		V	RFA	UPPER
ALUMINUM	B200689	BH06890003	30300	30300	484	MG/KG			RFA	UPPER
ALUMINUM	B200789	BH07890103	31800	31800	504	MG/KG			RFA	UPPER
ALUMINUM	B200989	BH09890104	40700	40700	40	MG/KG		E	RFA	UPPER
ALUMINUM	B400289	BH02894248	102000	102000	40	MG/KG		V	RFA	UPPER
ARSENIC	B201089	BH10890106	1	0 5	2	MG/KG	UJ	A	COL	UPPER
ARSENIC	B301889	BH15890309	5 5	2 75	2	MG/KG	UJ	A	COL	UPPER
ARSENIC	B301889	BH15890915	5 8	2 9	2	MG/KG	UJ	A	COL	UPPER
ARSENIC	B200589	BH05892325	1 9	0 95	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B200689	BH06891618	0 54	0 27	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B200689	BH06891824	0 63	0 315	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B200689	BH06890410	1 2	0 6	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B200889	BH08891420	4 45	2.225	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B200889	BH08890608	3 2	1 6	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B200889	BH08892022	3.2	1 6	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B200889	BH08890814	3 5	1 75	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B200889	BH08890106	5 9	2 95	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B400289	BH02893036	2 1	1 05	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B400389	BH03892733	1 2	0 6	2	MG/KG	UJ	A	RFA	UPPER
ARSENIC	B201189	BH11890915	1 85	0 925	2	MG/KG	U	V	COL	UPPER
ARSENIC	B201189	BH11892127	2	1	2	MG/KG	U	V	COL	UPPER
ARSENIC	B201589	BH14890003	2 3	1 15	2 3	MG/KG	U		COL	UPPER
ARSENIC	B401989	BH16890915	2 2	1 1	2	MG/KG	U	V	COL	UPPER
ARSENIC	B200689	BH06891016	2 2	1 1	2 2	MG/KG	U		RFA	UPPER
ARSENIC	B200789	BH07892426	2	1	2	MG/KG	U	V	RFA	UPPER
ARSENIC	B400289	BH02891521	1 95	0 975	2 1	MG/KG	U		RFA	UPPER
ARSENIC	B400289	BH02894248	17 9	8 95	2	MG/KG	U	V	RFA	UPPER
ARSENIC	B400489	BH04891521	2 45	1 225	2	MG/KG	U	V	RFA	UPPER
ARSENIC	B400489	BH04894046	2 4	1 2	2 4	MG/KG	U	A	RFA	UPPER
ARSENIC	B400489	BH04894652	2 4	1 2	2 4	MG/KG	U	A	RFA	UPPER
ARSENIC	B400489	BH04895254	2 4	1 2	2 4	MG/KG	U	A	RFA	UPPER
ARSENIC	B400489	BH04893335	2 8	1 4	2 8	MG/KG	U	A	RFA	UPPER
ARSENIC	B400489	BH04893840	2 9	1 45	2 9	MG/KG	U	A	RFA	UPPER
ARSENIC	B400489	BH04893538	4 9	2 45	4 9	MG/KG	U	A	RFA	UPPER
ARSENIC	B201089	BH10890003	5 2	5 2	2	MG/KG	J	A	COL	UPPER
ARSENIC	B201289	BH12890307	2 3	2 3	2	MG/KG	J	A	COL	UPPER
ARSENIC	B201289	BH12890915	2 4	2 4	2	MG/KG	J	A	COL	UPPER
ARSENIC	B201289	BH12891521	2 6	2 6	2	MG/KG	J	A	COL	UPPER
ARSENIC	B201489	BH13890307	2 4	2 4	2	MG/KG	J	A	COL	UPPER
ARSENIC	B301889	BH15891521	6 6	6 6	2	MG/KG	J	A	COL	UPPER
ARSENIC	B302089	BH17890306	3 7	3 7	2	MG/KG	J	A	COL	UPPER
ARSENIC	B402189	BH18890003	4 7	4 7	2	MG/KG	J	A	COL	UPPER
ARSENIC	B402189	BH18890307	4 8	4 8	2	MG/KG	J	A	COL	UPPER
ARSENIC	B200589	BH05891317	2 23	2 23	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200589	BH05891723	0 92	0 92	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200589	BH05890308	4	4	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200589	BH05890913	7 3	7 3	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200589	BH05892530	1 7	1 7	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200689	BH06892430	2 6	2 6	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200689	BH06890104	41 8	41 8	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200789	BH07890612	2 6	2 6	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200789	BH07891824	2 7	2 7	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200789	BH07890003	6 5	6 5	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200889	BH08890003	5 9	5 9	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200989	BH09890410	1 2	1 2	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200989	BH09891620	1 8	1 8	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200989	BH09891016	4	4	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200989	BH09890104	8	8	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B200989	BH09890003	8 1	8 1	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B400289	BH02892130	2 7	2 7	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B400389	BH03893339	2 7	2 7	2	MG/KG	J	A	RFA	UPPER

Analyte	Location	Sample	Result	Censored Result	Detection Limit	Units	Lab Qualifier	Validation Code	Geologic Unit	Hydro Unit
ARSENIC	B400389	BH03892127	1 9	1 9	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B400389	BH03891521	2 3	2 3	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B400389	BH03890915	2 5	2 5	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B400389	BH03890309	3 1	3 1	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B400389	BH03890003	5	5	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B400389	BH03893945	4 3	4 3	2	MG/KG	J	A	RFA	UPPER
ARSENIC	B405189	BH01892127	2 2	2 2	2	MG/KG	J	A	WCS	UPPER
ARSENIC	B405189	BH01890309	3 5	3 5	2	MG/KG	J	A	WCS	UPPER
ARSENIC	B405189	BH01890003	4	4	2	MG/KG	J	A	WCS	UPPER
ARSENIC	B405189	BH01890915	4 3	4 3	2	MG/KG	J	A	WCS	UPPER
ARSENIC	B405189	BH01893638	1 8	1 8	2	MG/KG	J	A	WCS	UPPER
ARSENIC	B405189	BH01893844	2 7	2 7	2	MG/KG	J	A	WCS	UPPER
ARSENIC	B405189	BH01893036	3	3	2	MG/KG	J	A	WCS	UPPER
ARSENIC	B405189	BH01894448	5 3	5 3	2	MG/KG	J	A	WCS	UPPER
ARSENIC	B201589	BH14890307	1 7	1 7	2	MG/KG	B	V	COL	UPPER
ARSENIC	B201189	BH11892733	2 8	2 8	2	MG/KG		V	COL	UPPER
ARSENIC	B201189	BH11890003	3 1	3 1	2 4	MG/KG			COL	UPPER
ARSENIC	B201189	BH11891521	5 2	5 2	2	MG/KG		V	COL	UPPER
ARSENIC	B201189	BH11890309	6 5	6 5	2	MG/KG		V	COL	UPPER
ARSENIC	B201289	BH12890003	3 2	3 2	2 4	MG/KG			COL	UPPER
ARSENIC	B201489	BH13890003	4 1	4 1	2 1	MG/KG			COL	UPPER
ARSENIC	B301889	BH15890003	5	5	2 5	MG/KG			COL	UPPER
ARSENIC	B302089	BH17890003	5 1	5 1	2 4	MG/KG			COL	UPPER
ARSENIC	B401989	BH16890309	3 2	3 2	2	MG/KG		V	COL	UPPER
ARSENIC	B401989	BH16891519	3 4	3 4	2	MG/KG		V	COL	UPPER
ARSENIC	B401989	BH16890003	4 8	4 8	2 4	MG/KG			COL	UPPER
ARSENIC	B200589	BH05890003	6	6	2 6	MG/KG			RFA	UPPER
ARSENIC	B200589	BH05890003F	6	6	2 6	MG/KG			RFA	UPPER
ARSENIC	B200689	BH06890003	4 4	4 4	2 5	MG/KG			RFA	UPPER
ARSENIC	B200789	BH07891218	3 1	3 1	2	MG/KG		V	RFA	UPPER
ARSENIC	B200789	BH07890306	4 1	4 1	2	MG/KG		V	RFA	UPPER
ARSENIC	B200789	BH07890103	10	10	2 4	MG/KG			RFA	UPPER
ARSENIC	B400289	BH02890915	4 8	4 8	2	MG/KG		V	RFA	UPPER
ARSENIC	B400289	BH02890003	7 3	7 3	2	MG/KG		V	RFA	UPPER
ARSENIC	B400289	BH02890309	9 4	9 4	2	MG/KG		V	RFA	UPPER
ARSENIC	B400289	BH02893642	2 4	2 4	2	MG/KG		V	RFA	UPPER
ARSENIC	B400389	BH03894548	2 9	2 9	2 1	MG/KG			RFA	UPPER
ARSENIC	B400489	BH04892127	2 4	2 4	2	MG/KG		V	RFA	UPPER
ARSENIC	B400489	BH04890915	3 1	3 1	2	MG/KG		V	RFA	UPPER
ARSENIC	B400489	BH04890309	4.2	4.2	2	MG/KG		V	RFA	UPPER
ARSENIC	B400489	BH04890003	5 5	5 5	2	MG/KG		V	RFA	UPPER
ARSENIC	B400489	BH04892733	2 5	2 5	2 1	MG/KG			RFA	UPPER
ARSENIC	B405189	BH01891521	1.2	1.2	2	MG/KG		A	WCS	UPPER
BARIUM	B201189	BH11891521	46 95	23.475	40	MG/KG	U	V	COL	UPPER
BARIUM	B200789	BH07891824	25 8	12 9	40	MG/KG	U	V	RFA	UPPER
BARIUM	B200789	BH07892426	29 3	14 65	40	MG/KG	U	V	RFA	UPPER
BARIUM	B200789	BH07891218	38 8	19 4	40	MG/KG	U	V	RFA	UPPER
BARIUM	B400289	BH02890003	42 8	21 4	40	MG/KG	U	V	RFA	UPPER
BARIUM	B400389	BH03890003	33 95	16 975	40	MG/KG	U	V	RFA	UPPER
BARIUM	B400389	BH03890309	40 6	20 3	40	MG/KG	U	V	RFA	UPPER
BARIUM	B400489	BH04890003	46	23	40	MG/KG	U	V	RFA	UPPER
BARIUM	B400489	BH04894652	46 2	23 1	46 2	MG/KG	U	A	RFA	UPPER
BARIUM	B400489	BH04894046	50 1	25 05	50 1	MG/KG	U	A	RFA	UPPER
BARIUM	B405189	BH01890309	38 2	19 1	40	MG/KG	U	V	WCS	UPPER
BARIUM	B201289	BH12890307	69 2	69 2	40	MG/KG	J	A	COL	UPPER
BARIUM	B201289	BH12891521	73	73	40	MG/KG	J	A	COL	UPPER
BARIUM	B201289	BH12890915	102	102	40	MG/KG	J	A	COL	UPPER
BARIUM	B201489	BH13890307	100 55	100 55	40	MG/KG	J	A	COL	UPPER
BARIUM	B301889	BH15890915	115	115	40	MG/KG	J	A	COL	UPPER
BARIUM	B301889	BH15891521	122	122	40	MG/KG	J	A	COL	UPPER
BARIUM	B301889	BH15890309	250	250	40	MG/KG	J	A	COL	UPPER
BARIUM	B200589	BH05891723	31 5	31 5	40	MG/KG	J	V	RFA	UPPER
BARIUM	B200589	BH05890913	18 8	18 8	40	MG/KG	J	V	RFA	UPPER
BARIUM	B200589	BH05892325	46 8	46 8	40	MG/KG	J	V	RFA	UPPER
BARIUM	B200589	BH05892530	20	20	40	MG/KG	J	A	RFA	UPPER
BARIUM	B200889	BH08890608	114 4	114 4	40	MG/KG	J	A	RFA	UPPER
BARIUM	B200889	BH08891420	43 8	43 8	40	MG/KG	J	A	RFA	UPPER
BARIUM	B200889	BH08890814	49	49	40	MG/KG	J	A	RFA	UPPER
BARIUM	B200889	BH08892022	128	128	40	MG/KG	J	A	RFA	UPPER
BARIUM	B200889	BH08890106	148	148	40	MG/KG	J	A	RFA	UPPER
BARIUM	B200889	BH08890003	121	121	40	MG/KG	J	V	RFA	UPPER
BARIUM	B200989	BH09890003	124	124	40	MG/KG	J	V	RFA	UPPER
BARIUM	B405189	BH01893844	44 9	44 9	40	MG/KG	J	A	WCS	UPPER
BARIUM	B405189	BH01894448	59 8	59 8	40	MG/KG	J	A	WCS	UPPER
BARIUM	B405189	BH01893638	68 6	68 6	40	MG/KG	J	A	WCS	UPPER
BARIUM	B405189	BH01893036	83 2	83 2	40	MG/KG	J	A	WCS	UPPER
BARIUM	B201089	BH10890106	95 3	95 3	40	MG/KG		V	COL	UPPER

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Table A 85 Subsurface Soil Background Inorganc Data										
Analyte	Location	Sample	Result	Censored Result	Detection Limit	Units	Lab Result Qualifier	Validation Code	Geologic Unit	Flow Unit
BARIUM	B201089	BH10890003	101	101	40	MG/KG		V	COL	UPPER
BARIUM	B201189	BH11890003	73 2	73 2	47	MG/KG			COL	UPPER
BARIUM	B201189	BH11890309	86 4	86 4	40	MG/KG		V	COL	UPPER
BARIUM	B201189	BH11892733	96 4	96 4	40	MG/KG		V	COL	UPPER
BARIUM	B201189	BH11890915	114	114	40	MG/KG		V	COL	UPPER
BARIUM	B201189	BH11892127	124	124	40	MG/KG		V	COL	UPPER
BARIUM	B201289	BH12890003	189	189	48 1	MG/KG			COL	UPPER
BARIUM	B201489	BH13890003	99 7	99 7	43 2	MG/KG			COL	UPPER
BARIUM	B201589	BH14890307	60 9	60 9	40	MG/KG		V	COL	UPPER
BARIUM	B201589	BH14890003	86 3	86 3	44 2	MG/KG			COL	UPPER
BARIUM	B301889	BH15890003	171	171	49 5	MG/KG			COL	UPPER
BARIUM	B302089	BH17890306	94 7	94 7	40	MG/KG		V	COL	UPPER
BARIUM	B302089	BH17890003	313	313	48 2	MG/KG			COL	UPPER
BARIUM	B401989	BH16891519	58 1	58 1	40	MG/KG		V	COL	UPPER
BARIUM	B401989	BH16890915	129	129	40	MG/KG		V	COL	UPPER
BARIUM	B401989	BH16890309	257	257	40	MG/KG		V	COL	UPPER
BARIUM	B401989	BH16890003	491	491	48 4	MG/KG			COL	UPPER
BARIUM	B402189	BH18890003	102	102	40	MG/KG		V	COL	UPPER
BARIUM	B402189	BH18890307	109	109	40	MG/KG		V	COL	UPPER
BARIUM	B200589	BH05890308	48 4	48 4	40	MG/KG		V	RFA	UPPER
BARIUM	B200589	BH05891317	54 2	54 2	40	MG/KG		V	RFA	UPPER
BARIUM	B200589	BH05890003	137	137	52 2	MG/KG			RFA	UPPER
BARIUM	B200589	BH05890003F	137	137	52.2	MG/KG			RFA	UPPER
BARIUM	B200689	BH06891016	47	47	43 3	MG/KG			RFA	UPPER
BARIUM	B200689	BH06890410	54 6	54 6	40	MG/KG		V	RFA	UPPER
BARIUM	B200689	BH06892430	58 5	58 5	40	MG/KG		V	RFA	UPPER
BARIUM	B200689	BH06890104	76	76	40	MG/KG		V	RFA	UPPER
BARIUM	B200689	BH06891618	104	104	40	MG/KG		V	RFA	UPPER
BARIUM	B200689	BH06891824	120	120	40	MG/KG		V	RFA	UPPER
BARIUM	B200689	BH06890003	107	107	48 4	MG/KG			RFA	UPPER
BARIUM	B200789	BH07890612	46 5	46 5	40	MG/KG		V	RFA	UPPER
BARIUM	B200789	BH07890306	133	133	40	MG/KG		V	RFA	UPPER
BARIUM	B200789	BH07890103	195	195	50 4	MG/KG			RFA	UPPER
BARIUM	B200789	BH07890003	120	120	40	MG/KG		V	RFA	UPPER
BARIUM	B200989	BH09891016	38 7	38 7	40	MG/KG		V	RFA	UPPER
BARIUM	B200989	BH09891620	53 1	53 1	40	MG/KG		V	RFA	UPPER
BARIUM	B200989	BH09890410	57 9	57 9	40	MG/KG		V	RFA	UPPER
BARIUM	B200989	BH09890104	209	209	40	MG/KG		V	RFA	UPPER
BARIUM	B400289	BH02890309	68 9	68 9	40	MG/KG		V	RFA	UPPER
BARIUM	B400289	BH02890915	81 7	81 7	40	MG/KG		V	RFA	UPPER
BARIUM	B400289	BH02892130	49 85	49 85	40	MG/KG		V	RFA	UPPER
BARIUM	B400289	BH02891521	54 6	54 6	44 9	MG/KG			RFA	UPPER
BARIUM	B400289	BH02893642	60 5	60 5	40	MG/KG		V	RFA	UPPER
BARIUM	B400289	BH02893036	72 8	72.8	40	MG/KG		V	RFA	UPPER
BARIUM	B400289	BH02894248	777	777	40	MG/KG		V	RFA	UPPER
BARIUM	B400389	BH03892733	56 2	56 2	40	MG/KG		V	RFA	UPPER
BARIUM	B400389	BH03892127	50 8	50 8	40	MG/KG		V	RFA	UPPER
BARIUM	B400389	BH03891521	56 8	56 8	40	MG/KG		V	RFA	UPPER
BARIUM	B400389	BH03890915	60 9	60 9	40	MG/KG		V	RFA	UPPER
BARIUM	B400389	BH03893339	73 1	73 1	40	MG/KG		V	RFA	UPPER
BARIUM	B400389	BH03894548	73 2	73 2	42.3	MG/KG			RFA	UPPER
BARIUM	B400389	BH03893945	159	159	40	MG/KG		V	RFA	UPPER
BARIUM	B400489	BH04890309	50 4	50 4	40	MG/KG		V	RFA	UPPER
BARIUM	B400489	BH04890915	51 1	51 1	40	MG/KG		V	RFA	UPPER
BARIUM	B400489	BH04892127	71 9	71 9	40	MG/KG		V	RFA	UPPER
BARIUM	B400489	BH04891521	73 2	73 2	40	MG/KG		V	RFA	UPPER
BARIUM	B400489	BH04895254	64 3	64 3	46	MG/KG		A	RFA	UPPER
BARIUM	B400489	BH04893840	76 6	76 6	60 4	MG/KG		A	RFA	UPPER
BARIUM	B400489	BH04892733	85 5	85 5	42 3	MG/KG			RFA	UPPER
BARIUM	B400489	BH04893335	90 9	90 9	55 3	MG/KG		A	RFA	UPPER
BARIUM	B400489	BH04893538	148	148	96 8	MG/KG		A	RFA	UPPER
BARIUM	B405189	BH01890003	61 2	61 2	40	MG/KG		V	WCS	UPPER
BARIUM	B405189	BH01892127	61 7	61 7	40	MG/KG		V	WCS	UPPER
BARIUM	B405189	BH01891521	68 8	68 8	40	MG/KG		V	WCS	UPPER
BARIUM	B405189	BH01890915	116	116	40	MG/KG		V	WCS	UPPER
CADMIUM	B201089	BH10890106	1 1	0 55	1	MG/KG	UJ	A	COL	UPPER
CADMIUM	B201289	BH12890307	1 1	0 55	1	MG/KG	UJ	A	COL	UPPER
CADMIUM	B201289	BH12891521	1 2	0 6	1	MG/KG	UJ	A	COL	UPPER
CADMIUM	B301889	BH15891521	1 8	0 9	1	MG/KG	UJ	A	COL	UPPER
CADMIUM	B302089	BH17890306	0 59	0.295	1	MG/KG	UJ	A	COL	UPPER
CADMIUM	B401989	BH16890915	0 21	0 105	1	MG/KG	UJ	A	COL	UPPER
CADMIUM	B402189	BH18890003	0 2	0 1	1	MG/KG	UJ	A	COL	UPPER
CADMIUM	B402189	BH18890307	0 3	0 15	1	MG/KG	UJ	A	COL	UPPER
CADMIUM	B200689	BH06891824	1	0 5	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B200689	BH06890104	1 1	0 55	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B200689	BH06890410	1 1	0 55	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B200689	BH06892430	1 1	0 55	1	MG/KG	UJ	A	RFA	UPPER

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Table A 85 Subsurface Soil Background Inorganc Data										
Analyte	Location	Sample	Result	Censored Result	Detection Limit	Units	Lab Qualifier	Validation Code	Geologic Unit	Flow Unit
CADMIUM	B200689	BH06891618	1 2	0 6	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B200789	BH07890306	1	0 5	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B200789	BH07891824	1	0 5	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B200789	BH07892426	1 1	0 55	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B200989	BH09891016	1 045	0 5225	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B400289	BH02892130	0 18	0 09	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B400289	BH02893036	0 18	0 09	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B400289	BH02893642	0 18	0 09	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B400289	BH02894248	2 3	1 15	1	MG/KG	UJ	A	RFA	UPPER
CADMIUM	B201089	BH10890003	1 1	0 55	1	MG/KG	U	V	COL	UPPER
CADMIUM	B201189	BH11890309	1 1	0 55	1	MG/KG	U	V	COL	UPPER
CADMIUM	B201189	BH11890915	1 1	0 55	1	MG/KG	U	V	COL	UPPER
CADMIUM	B201189	BH11891521	1 1	0 55	1	MG/KG	U	V	COL	UPPER
CADMIUM	B201189	BH11892127	1 1	0 55	1	MG/KG	U	V	COL	UPPER
CADMIUM	B201189	BH11890003	1 2	0 6	1 2	MG/KG	U		COL	UPPER
CADMIUM	B201189	BH11892733	1 2	0 6	1	MG/KG	U	V	COL	UPPER
CADMIUM	B201289	BH12890003	1 2	0 6	1 2	MG/KG	U		COL	UPPER
CADMIUM	B201489	BH13890003	1 1	0 55	1 1	MG/KG	U		COL	UPPER
CADMIUM	B201489	BH13890307	1 1	0 55	1	MG/KG	U	V	COL	UPPER
CADMIUM	B201589	BH14890003	1 1	0 55	1 1	MG/KG	U		COL	UPPER
CADMIUM	B201589	BH14890307	1 2	0 6	1	MG/KG	U	V	COL	UPPER
CADMIUM	B301889	BH15890309	1 1	0 55	1	MG/KG	U	V	COL	UPPER
CADMIUM	B301889	BH15890915	1 1	0 55	1	MG/KG	U	V	COL	UPPER
CADMIUM	B301889	BH15890003	1 2	0 6	1 2	MG/KG	U		COL	UPPER
CADMIUM	B302089	BH17890003	1 2	0 6	1 2	MG/KG	U		COL	UPPER
CADMIUM	B401989	BH16890003	1 2	0 6	1 2	MG/KG	U		COL	UPPER
CADMIUM	B200589	BH05891723	1 45	0 725	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B200589	BH05892325	1 2	0 6	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B200589	BH05890003	1 3	0 65	1 3	MG/KG	U		RFA	UPPER
CADMIUM	B200589	BH05890003R	1 3	0 65	1 3	MG/KG	U		RFA	UPPER
CADMIUM	B200689	BH06891016	1 1	0 55	1 1	MG/KG	U		RFA	UPPER
CADMIUM	B200689	BH06890003	1.2	0 6	1.2	MG/KG	U		RFA	UPPER
CADMIUM	B200789	BH07890103	1 3	0 65	1 3	MG/KG	U		RFA	UPPER
CADMIUM	B200789	BH07890003	1 1	0 55	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B200889	BH08890106	1 1	0 55	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B200889	BH08890608	1 1	0 55	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B200889	BH08890814	1 1	0 55	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B200889	BH08891420	1 1	0 55	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B200889	BH08892022	1 1	0 55	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B200889	BH08890003	1 2	0 6	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B200989	BH09890003	1 1	0 55	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B400289	BH02891521	1 1	0 55	1 1	MG/KG	U		RFA	UPPER
CADMIUM	B400389	BH03891521	0 16	0 08	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B400389	BH03890309	0 17	0 085	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B400389	BH03890915	0 17	0 085	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B400389	BH03893945	0 19	0 095	1	MG/KG	U	V	RFA	UPPER
CADMIUM	B400389	BH03894548	1 1	0 55	1 1	MG/KG	U		RFA	UPPER
CADMIUM	B400489	BH04892733	1 1	0 55	1 1	MG/KG	U		RFA	UPPER
CADMIUM	B400489	BH04895254	1 1	0 55	1 1	MG/KG	U	A	RFA	UPPER
CADMIUM	B400489	BH04894652	1.2	0 6	1 2	MG/KG	U	A	RFA	UPPER
CADMIUM	B400489	BH04894046	1 3	0 65	1 3	MG/KG	U	A	RFA	UPPER
CADMIUM	B400489	BH04893335	1 4	0 7	1 4	MG/KG	U	A	RFA	UPPER
CADMIUM	B400489	BH04893840	1 5	0 75	1 5	MG/KG	U	A	RFA	UPPER
CADMIUM	B400489	BH04893538	2 4	1 2	2 4	MG/KG	U	A	RFA	UPPER
CADMIUM	B405189	BH01890003	1	0 5	1	MG/KG	U	V	WCS	UPPER
CADMIUM	B405189	BH01890309	1	0 5	1	MG/KG	U	V	WCS	UPPER
CADMIUM	B405189	BH01891521	1	0 5	1	MG/KG	U	V	WCS	UPPER
CADMIUM	B405189	BH01890915	1 1	0 55	1	MG/KG	U	V	WCS	UPPER
CADMIUM	B405189	BH01892127	1 1	0 55	1	MG/KG	U	V	WCS	UPPER
CADMIUM	B405189	BH01893844	0 97	0 485	1	MG/KG	U	V	WCS	UPPER
CADMIUM	B405189	BH01893036	1	0 5	1	MG/KG	U	V	WCS	UPPER
CADMIUM	B405189	BH01893638	1	0 5	1	MG/KG	U	V	WCS	UPPER
CADMIUM	B405189	BH01894448	1	0 5	1	MG/KG	U	V	WCS	UPPER
CADMIUM	B201289	BH12890915	1 1	1 1	1	MG/KG	J	A	COL	UPPER
CADMIUM	B200789	BH07891218	1 3	1 3	1	MG/KG	J	A	RFA	UPPER
CADMIUM	B200789	BH07890612	1 5	1 5	1	MG/KG	J	A	RFA	UPPER
CADMIUM	B200589	BH05890913	1 3	1 3	1	MG/KG		V	RFA	UPPER
CADMIUM	B200589	BH05890308	1 4	1 4	1	MG/KG		V	RFA	UPPER
CADMIUM	B200589	BH05891317	1 5	1 5	1	MG/KG		V	RFA	UPPER
CHROMIUM	B301889	BH15891521	15	7 5	2	MG/KG	UJ	A	COL	UPPER
CHROMIUM	B301889	BH15890309	16 4	8 2	2	MG/KG	UJ	A	COL	UPPER
CHROMIUM	B301889	BH15890915	17 7	8 85	2	MG/KG	UJ	A	COL	UPPER
CHROMIUM	B200589	BH05892325	6 3	3 15	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200589	BH05891723	4 1	2 05	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200589	BH05890913	7	3 5	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200589	BH05890308	8 4	4 2	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200889	BH08892022	14 8	7 4	2	MG/KG	UJ	A	RFA	UPPER

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Table A 85 Subsurface Soil Background Inorganc Data										
Analyte	Location	Sample	Result	Censored Result	Detection Limit	Units	Lab Qualifier	Validation Code	Geologic Unit	Flow Unit
CHROMIUM	B200889	BH08891420	9 5	4 75	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200889	BH08890814	12 7	6 35	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200889	BH08890106	17 4	8 7	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200889	BH08890608	17 8	8 9	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200989	BH09890410	5 9	2 95	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200989	BH09891016	7 9	3 95	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B200989	BH09891620	9 9	4 95	2	MG/KG	UJ	A	RFA	UPPER
CHROMIUM	B201189	BH11892733	6 3	6 3	2	MG/KG	J	A	COL	UPPER
CHROMIUM	B201189	BH11891521	7 1	7 1	2	MG/KG	J	A	COL	UPPER
CHROMIUM	B201189	BH11890309	7 2	7 2	2	MG/KG	J	A	COL	UPPER
CHROMIUM	B201189	BH11892127	7 2	7 2	2	MG/KG	J	A	COL	UPPER
CHROMIUM	B201189	BH11890915	7 9	7 9	2	MG/KG	J	A	COL	UPPER
CHROMIUM	B201289	BH12890307	17 4	17 4	2	MG/KG	J	A	COL	UPPER
CHROMIUM	B201289	BH12891521	9 8	9 8	2	MG/KG	J	A	COL	UPPER
CHROMIUM	B201289	BH12890915	11 4	11 4	2	MG/KG	J	A	COL	UPPER
CHROMIUM	B200789	BH07891824	6 8	6 8	2	MG/KG	J	A	RFA	UPPER
CHROMIUM	B200789	BH07892426	7 9	7 9	2	MG/KG	J	A	RFA	UPPER
CHROMIUM	B200789	BH07890306	9 8	9 8	2	MG/KG	J	A	RFA	UPPER
CHROMIUM	B200789	BH07890612	15 5	15 5	2	MG/KG	J	A	RFA	UPPER
CHROMIUM	B200789	BH07891218	16 1	16 1	2	MG/KG	J	A	RFA	UPPER
CHROMIUM	B400289	BH02892130	10 5	10 5	2	MG/KG	J	A	RFA	UPPER
CHROMIUM	B400289	BH02893036	14 3	14 3	2	MG/KG	J	A	RFA	UPPER
CHROMIUM	B400289	BH02893642	174	174	2	MG/KG	J	A	RFA	UPPER
CHROMIUM	B201089	BH10890106	14	14	2	MG/KG		V	COL	UPPER
CHROMIUM	B201089	BH10890003	21 3	21 3	2	MG/KG		V	COL	UPPER
CHROMIUM	B201189	BH11890003	7 05	7 05	2 2	MG/KG			COL	UPPER
CHROMIUM	B201289	BH12890003	12 5	12 5	2 4	MG/KG			COL	UPPER
CHROMIUM	B201489	BH13890307	8 5	8 5	2	MG/KG		V	COL	UPPER
CHROMIUM	B201489	BH13890003	12 9	12 9	2 2	MG/KG			COL	UPPER
CHROMIUM	B201589	BH14890307	7 4	7 4	2	MG/KG		V	COL	UPPER
CHROMIUM	B201589	BH14890003	9 4	9 4	2 2	MG/KG			COL	UPPER
CHROMIUM	B301889	BH15890003	17 2	17 2	2 5	MG/KG			COL	UPPER
CHROMIUM	B302089	BH17890306	14 2	14 2	2	MG/KG		V	COL	UPPER
CHROMIUM	B302089	BH17890003	21 6	21 6	2 4	MG/KG			COL	UPPER
CHROMIUM	B401989	BH16891519	13.9	13 9	2	MG/KG		V	COL	UPPER
CHROMIUM	B401989	BH16890915	22 2	22 2	2	MG/KG		V	COL	UPPER
CHROMIUM	B401989	BH16890309	25 4	25 4	2	MG/KG		V	COL	UPPER
CHROMIUM	B401989	BH16890003	26 9	26 9	2 4	MG/KG			COL	UPPER
CHROMIUM	B402189	BH18890003	12 9	12 9	2	MG/KG		V	COL	UPPER
CHROMIUM	B402189	BH18890307	15 4	15 4	2	MG/KG		V	COL	UPPER
CHROMIUM	B200589	BH05891317	12 3	12 3	2	MG/KG		V	RFA	UPPER
CHROMIUM	B200589	BH05890003	16 4	16 4	2 6	MG/KG			RFA	UPPER
CHROMIUM	B200589	BH05892530	5 6	5 6	2	MG/KG		A	RFA	UPPER
CHROMIUM	B200589	BH05890003F	16 4	16 4	2 6	MG/KG			RFA	UPPER
CHROMIUM	B200689	BH06892430	9 7	9 7	2	MG/KG		V	RFA	UPPER
CHROMIUM	B200689	BH06891016	12	12	2 2	MG/KG			RFA	UPPER
CHROMIUM	B200689	BH06891618	14 3	14 3	2	MG/KG		V	RFA	UPPER
CHROMIUM	B200689	BH06891824	15	15	2	MG/KG		V	RFA	UPPER
CHROMIUM	B200689	BH06890104	48 7	48 7	2	MG/KG		V	RFA	UPPER
CHROMIUM	B200689	BH06890410	69 6	69 6	2	MG/KG		V	RFA	UPPER
CHROMIUM	B200689	BH06890003	27 1	27 1	2 4	MG/KG			RFA	UPPER
CHROMIUM	B200789	BH07890103	42 6	42 6	2 5	MG/KG			RFA	UPPER
CHROMIUM	B200789	BH07890003	19 4	19 4	2	MG/KG		V	RFA	UPPER
CHROMIUM	B200889	BH08890003	18 2	18 2	2	MG/KG		V	RFA	UPPER
CHROMIUM	B200989	BH09890104	34 5	34 5	2	MG/KG		V	RFA	UPPER
CHROMIUM	B200989	BH09890003	19 4	19 4	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400289	BH02890003	12 3	12 3	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400289	BH02890915	14 9	14 9	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400289	BH02890309	16 8	16 8	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400289	BH02891521	14 9	14 9	2 2	MG/KG			RFA	UPPER
CHROMIUM	B400289	BH02894248	176	176	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400389	BH03892733	17 8	17 8	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400389	BH03890309	13 5	13 5	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400389	BH03890003	13 8	13 8	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400389	BH03891521	16 1	16 1	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400389	BH03893339	17 7	17 7	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400389	BH03890915	18 2	18 2	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400389	BH03892127	21 6	21 6	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400389	BH03894548	11 2	11 2	2 1	MG/KG			RFA	UPPER
CHROMIUM	B400389	BH03893945	21 6	21 6	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400489	BH04892127	24 75	24 75	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400489	BH04891521	19 9	19 9	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400489	BH04890003	25 4	25 4	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400489	BH04890309	28 3	28 3	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400489	BH04890915	30 6	30 6	2	MG/KG		V	RFA	UPPER
CHROMIUM	B400489	BH04894652	5 6	5 6	2 3	MG/KG		A	RFA	UPPER
CHROMIUM	B400489	BH04895254	8 1	8 1	2 3	MG/KG		A	RFA	UPPER

Table A 85 Subsurface Soil Background Inorganc Data

Analyte	Location	Sample Number	Result	Censored Result	Detection Limit	Units	Lab Qualifier	Validation Code	Geologic Unit	Flow Unit
CHROMIUM	B400489	BH04894046	9 2	9 2	2 5	MG/KG		A	RFA	UPPER
CHROMIUM	B400489	BH04893335	14 1	14 1	2 8	MG/KG		A	RFA	UPPER
CHROMIUM	B400489	BH04892733	14 2	14 2	2 1	MG/KG			RFA	UPPER
CHROMIUM	B400489	BH04893840	19 2	19 2	3	MG/KG		A	RFA	UPPER
CHROMIUM	B400489	BH04893538	25 7	25 7	4 8	MG/KG		A	RFA	UPPER
CHROMIUM	B405189	BH01890309	15 4	15 4	2	MG/KG		V	WCS	UPPER
CHROMIUM	B405189	BH01892127	17 2	17 2	2	MG/KG		V	WCS	UPPER
CHROMIUM	B405189	BH01890003	23 1	23 1	2	MG/KG		V	WCS	UPPER
CHROMIUM	B405189	BH01891521	26 1	26 1	2	MG/KG		V	WCS	UPPER
CHROMIUM	B405189	BH01890915	31 7	31 7	2	MG/KG		V	WCS	UPPER
CHROMIUM	B405189	BH01893036	11 7	11 7	2	MG/KG		V	WCS	UPPER
CHROMIUM	B405189	BH01893638	18 8	18 8	2	MG/KG		V	WCS	UPPER
CHROMIUM	B405189	BH01894448	21 1	21 1	2	MG/KG		V	WCS	UPPER
CHROMIUM	B405189	BH01893844	21 2	21 2	2	MG/KG		V	WCS	UPPER
IRON	B201289	BH12890915	13730	13730	20	MG/KG	J	A	COL	UPPER
IRON	B201289	BH12891521	10900	10900	20	MG/KG	J	A	COL	UPPER
IRON	B200989	BH09890104	33700	33700	20	MG/KG	J	E	RFA	UPPER
IRON	B400289	BH02892130	9360	9360	20	MG/KG	J	A	RFA	UPPER
IRON	B400289	BH02893036	1300	1300	20	MG/KG	J	A	RFA	UPPER
IRON	B400289	BH02893642	10400	10400	20	MG/KG	J	A	RFA	UPPER
IRON	B200789	BH07890003	17600	17600	20	MG/KG	E		RFA	UPPER
IRON	B200889	BH08890003	15400	15400	20	MG/KG	E		RFA	UPPER
IRON	B200989	BH09890003	17900	17900	20	MG/KG	E		RFA	UPPER
IRON	B201089	BH10890106	18100	18100	20	MG/KG		V	COL	UPPER
IRON	B201089	BH10890003	19700	19700	20	MG/KG		V	COL	UPPER
IRON	B201189	BH11890003	8420	8420	21 75	MG/KG			COL	UPPER
IRON	B201189	BH11892127	7420	7420	20	MG/KG		V	COL	UPPER
IRON	B201189	BH11891521	8726	8726	20	MG/KG		V	COL	UPPER
IRON	B201189	BH11892733	9700	9700	20	MG/KG		V	COL	UPPER
IRON	B201189	BH11890309	10700	10700	20	MG/KG		V	COL	UPPER
IRON	B201189	BH11890915	11200	11200	20	MG/KG		V	COL	UPPER
IRON	B201289	BH12890307	10500	10500	20	MG/KG		A	COL	UPPER
IRON	B201289	BH12890003	11800	11800	24 1	MG/KG			COL	UPPER
IRON	B201489	BH13890307	9840	9840	20	MG/KG		V	COL	UPPER
IRON	B201489	BH13890003	14200	14200	21 6	MG/KG			COL	UPPER
IRON	B201589	BH14890307	9060	9060	20	MG/KG		V	COL	UPPER
IRON	B201589	BH14890003	17300	17300	22 1	MG/KG			COL	UPPER
IRON	B301889	BH15890309	18500	18500	20	MG/KG		A	COL	UPPER
IRON	B301889	BH15890915	27200	27200	20	MG/KG		A	COL	UPPER
IRON	B301889	BH15891521	28500	28500	20	MG/KG		A	COL	UPPER
IRON	B301889	BH15890003	35900	35900	248	MG/KG			COL	UPPER
IRON	B302089	BH17890306	13200	13200	20	MG/KG		V	COL	UPPER
IRON	B302089	BH17890003	20800	20800	24 1	MG/KG			COL	UPPER
IRON	B401989	BH16891519	9990	9990	20	MG/KG		V	COL	UPPER
IRON	B401989	BH16890915	14000	14000	20	MG/KG		V	COL	UPPER
IRON	B401989	BH16890309	17500	17500	20	MG/KG		V	COL	UPPER
IRON	B401989	BH16890003	18100	18100	24 2	MG/KG			COL	UPPER
IRON	B402189	BH18890003	12600	12600	20	MG/KG		V	COL	UPPER
IRON	B402189	BH18890307	13200	13200	20	MG/KG		V	COL	UPPER
IRON	B200589	BH05892325	11905	11905	20	MG/KG		V	RFA	UPPER
IRON	B200589	BH05891723	7590	7590	20	MG/KG		V	RFA	UPPER
IRON	B200589	BH05891317	13900	13900	20	MG/KG		V	RFA	UPPER
IRON	B200589	BH05890913	15700	15700	20	MG/KG		V	RFA	UPPER
IRON	B200589	BH05890003	19100	19100	26 1	MG/KG			RFA	UPPER
IRON	B200589	BH05890308	19800	19800	20	MG/KG		V	RFA	UPPER
IRON	B200589	BH05892530	8700	8700	20	MG/KG		V	RFA	UPPER
IRON	B200589	BH05890003R	19100	19100	26 1	MG/KG			RFA	UPPER
IRON	B200689	BH06891016	9340	9340	21 6	MG/KG			RFA	UPPER
IRON	B200689	BH06891824	11000	11000	20	MG/KG		V	RFA	UPPER
IRON	B200689	BH06890410	11100	11100	20	MG/KG		V	RFA	UPPER
IRON	B200689	BH06892430	11600	11600	20	MG/KG		V	RFA	UPPER
IRON	B200689	BH06891618	17600	17600	20	MG/KG		V	RFA	UPPER
IRON	B200689	BH06890104	18500	18500	20	MG/KG		V	RFA	UPPER
IRON	B200689	BH06890003	23900	23900	24 2	MG/KG			RFA	UPPER
IRON	B200789	BH07891824	5130	5130	20	MG/KG		V	RFA	UPPER
IRON	B200789	BH07892426	8180	8180	20	MG/KG		V	RFA	UPPER
IRON	B200789	BH07890612	9440	9440	20	MG/KG		V	RFA	UPPER
IRON	B200789	BH07890306	9590	9590	20	MG/KG		V	RFA	UPPER
IRON	B200789	BH07891218	11400	11400	20	MG/KG		V	RFA	UPPER
IRON	B200789	BH07890103	26600	26600	252	MG/KG			RFA	UPPER
IRON	B200889	BH08890608	13325	13325	20	MG/KG		V	RFA	UPPER
IRON	B200889	BH08891420	8400	8400	20	MG/KG		V	RFA	UPPER
IRON	B200889	BH08892022	8650	8650	20	MG/KG		V	RFA	UPPER
IRON	B200889	BH08890814	11900	11900	20	MG/KG		V	RFA	UPPER
IRON	B200889	BH08890106	15800	15800	20	MG/KG		V	RFA	UPPER
IRON	B200989	BH09890410	7645	7645	20	MG/KG		V	RFA	UPPER
IRON	B200989	BH09891016	9820	9820	20	MG/KG		V	RFA	UPPER

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Table A 85 Subsurface Soil Background Inorganc Data

Analyte	Location	Sample	Result	Censored Result	Detection Limit	Units	[illegible]	Validation Code	Geologic Unit	[illegible]
IRON	B200989	BH09891620	10400	10400	20	MG/KG		V	RFA	UPPER
IRON	B400289	BH02890915	10900	10900	20	MG/KG		V	RFA	UPPER
IRON	B400289	BH02890003	11000	11000	20	MG/KG		V	RFA	UPPER
IRON	B400289	BH02890309	11800	11800	20	MG/KG		V	RFA	UPPER
IRON	B400289	BH02891521	8845	8845	21 2	MG/KG			RFA	UPPER
IRON	B400289	BH02894248	132000	132000	20	MG/KG		V	RFA	UPPER
IRON	B400389	BH03892733	8360	8360	20	MG/KG		V	RFA	UPPER
IRON	B400389	BH03890003	8725	8725	20	MG/KG		V	RFA	UPPER
IRON	B400389	BH03890309	8710	8710	20	MG/KG		V	RFA	UPPER
IRON	B400389	BH03892127	8800	8800	20	MG/KG		V	RFA	UPPER
IRON	B400389	BH03891521	10700	10700	20	MG/KG		V	RFA	UPPER
IRON	B400389	BH03890915	10900	10900	20	MG/KG		V	RFA	UPPER
IRON	B400389	BH03893339	10900	10900	20	MG/KG		V	RFA	UPPER
IRON	B400389	BH03894548	10800	10800	21 2	MG/KG			RFA	UPPER
IRON	B400389	BH03893945	20300	20300	20	MG/KG		V	RFA	UPPER
IRON	B400489	BH04890003	10265	10265	20	MG/KG		V	RFA	UPPER
IRON	B400489	BH04891521	11100	11100	20	MG/KG		V	RFA	UPPER
IRON	B400489	BH04890915	11200	11200	20	MG/KG		V	RFA	UPPER
IRON	B400489	BH04890309	12700	12700	20	MG/KG		V	RFA	UPPER
IRON	B400489	BH04892127	13200	13200	20	MG/KG		V	RFA	UPPER
IRON	B400489	BH04894652	4670	4670	23.1	MG/KG		A	RFA	UPPER
IRON	B400489	BH04894046	5870	5870	25	MG/KG		A	RFA	UPPER
IRON	B400489	BH04895254	8200	8200	23	MG/KG		A	RFA	UPPER
IRON	B400489	BH04892733	11400	11400	21 1	MG/KG			RFA	UPPER
IRON	B400489	BH04893840	12300	12300	30 2	MG/KG		A	RFA	UPPER
IRON	B400489	BH04893335	13100	13100	27 7	MG/KG		A	RFA	UPPER
IRON	B400489	BH04893538	22000	22000	48.4	MG/KG		A	RFA	UPPER
IRON	B405189	BH01890309	8860	8860	20	MG/KG		V	WCS	UPPER
IRON	B405189	BH01891521	10200	10200	20	MG/KG		V	WCS	UPPER
IRON	B405189	BH01892127	11800	11800	20	MG/KG		V	WCS	UPPER
IRON	B405189	BH01890003	15900	15900	20	MG/KG		V	WCS	UPPER
IRON	B405189	BH01890915	20700	20700	20	MG/KG		V	WCS	UPPER
IRON	B405189	BH01893036	12800	12800	20	MG/KG		V	WCS	UPPER
IRON	B405189	BH01893844	13800	13800	20	MG/KG		V	WCS	UPPER
IRON	B405189	BH01894448	14200	14200	20	MG/KG		V	WCS	UPPER
IRON	B405189	BH01893638	20100	20100	20	MG/KG		V	WCS	UPPER
MANGANESE	B201089	BH10890106	145	145	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201089	BH10890003	303	303	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201189	BH11892127	90 1	90 1	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201189	BH11892733	98 4	98 4	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201189	BH11890915	141	141	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201189	BH11891521	149	149	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201189	BH11890309	281	281	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201289	BH12890307	128	128	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201289	BH12890915	115	115	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201289	BH12891521	161	161	3	MG/KG	J	A	COL	UPPER
MANGANESE	B201489	BH13890307	62 2	62 2	3	MG/KG	J	A	COL	UPPER
MANGANESE	B301889	BH15890915	318	318	3	MG/KG	J	A	COL	UPPER
MANGANESE	B301889	BH15890309	462	462	3	MG/KG	J	A	COL	UPPER
MANGANESE	B301889	BH15891521	511	511	3	MG/KG	J	A	COL	UPPER
MANGANESE	B302089	BH17890306	68 25	68 25	3	MG/KG	J	A	COL	UPPER
MANGANESE	B402189	BH18890003	75 7	75 7	3	MG/KG	J	A	COL	UPPER
MANGANESE	B402189	BH18890307	91 9	91 9	3	MG/KG	J	A	COL	UPPER
MANGANESE	B200689	BH06890410	79 8	79 8	3	MG/KG	J	V	RFA	UPPER
MANGANESE	B200689	BH06890104	85 7	85 7	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200689	BH06892430	222	222	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200689	BH06891618	226	226	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200689	BH06891824	656	656	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200889	BH08890608	205 3	205 3	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200889	BH08891420	112	112	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200889	BH08890814	120	120	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200889	BH08890106	136	136	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200889	BH08892022	446	446	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200989	BH09890410	85 15	85 15	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200989	BH09891620	125	125	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200989	BH09891016	195	195	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B200989	BH09890104	254	254	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B400289	BH02892130	136	136	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B400289	BH02893036	136	136	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B400289	BH02893642	189	189	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B400289	BH02894248	3330	3330	3	MG/KG	J	A	RFA	UPPER
MANGANESE	B405189	BH01890003	39 9	39 9	3	MG/KG	J	A	WCS	UPPER
MANGANESE	B405189	BH01890309	104	104	3	MG/KG	J	A	WCS	UPPER
MANGANESE	B405189	BH01892127	163	163	3	MG/KG	J	A	WCS	UPPER
MANGANESE	B405189	BH01891521	199	199	3	MG/KG	J	A	WCS	UPPER
MANGANESE	B405189	BH01890915	377	377	3	MG/KG	J	A	WCS	UPPER
MANGANESE	B405189	BH01893844	112	112	3	MG/KG	J	A	WCS	UPPER

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Table A 85 Subsurface Soil Background Inorganc Data										
Analyte	Location	Sample	Result	Censored Result	Detection Limit	Units	Lab Qualifier	Validation Code	Geologic Unit	[illegible]
MANGANESE	B405189	BH01893638	121	121	3	MG/KG	J	A	WCS	UPPER
MANGANESE	B405189	BH01894448	172	172	3	MG/KG	J	A	WCS	UPPER
MANGANESE	B405189	BH01893036	259	259	3	MG/KG	J	A	WCS	UPPER
MANGANESE	B201589	BH14890307	103	103	3	MG/KG	E		COL	UPPER
MANGANESE	B200789	BH07890003	210	210	3	MG/KG	E		RFA	UPPER
MANGANESE	B200889	BH08890003	217	217	3	MG/KG	E		RFA	UPPER
MANGANESE	B200989	BH09890003	197	197	3	MG/KG	E		RFA	UPPER
MANGANESE	B201189	BH11890003	237	237	3 5	MG/KG			COL	UPPER
MANGANESE	B201289	BH12890003	195	195	3 6	MG/KG			COL	UPPER
MANGANESE	B201489	BH13890003	110	110	3 2	MG/KG			COL	UPPER
MANGANESE	B201589	BH14890003	231	231	3 3	MG/KG			COL	UPPER
MANGANESE	B301889	BH15890003	747	747	3 7	MG/KG			COL	UPPER
MANGANESE	B302089	BH17890003	260	260	3 6	MG/KG			COL	UPPER
MANGANESE	B401989	BH16891519	37	37	3	MG/KG		V	COL	UPPER
MANGANESE	B401989	BH16890309	76 9	76 9	3	MG/KG		V	COL	UPPER
MANGANESE	B401989	BH16890915	77 4	77 4	3	MG/KG		V	COL	UPPER
MANGANESE	B401989	BH16890003	97 4	97 4	3 6	MG/KG			COL	UPPER
MANGANESE	B200589	BH05892325	178 15	178 15	3	MG/KG		V	RFA	UPPER
MANGANESE	B200589	BH05891723	69 8	69 8	3	MG/KG		V	RFA	UPPER
MANGANESE	B200589	BH05890003	103	103	3 9	MG/KG			RFA	UPPER
MANGANESE	B200589	BH05890913	124	124	3	MG/KG		V	RFA	UPPER
MANGANESE	B200589	BH05891317	179	179	3	MG/KG		V	RFA	UPPER
MANGANESE	B200589	BH05890306	346	346	3	MG/KG		V	RFA	UPPER
MANGANESE	B200589	BH05892530	110	110	3	MG/KG		V	RFA	UPPER
MANGANESE	B200589	BH05890003F	103	103	3 9	MG/KG			RFA	UPPER
MANGANESE	B200689	BH06891016	89 7	89 7	3 2	MG/KG			RFA	UPPER
MANGANESE	B200689	BH06890003	102	102	3 6	MG/KG			RFA	UPPER
MANGANESE	B200789	BH07890306	66 4	66 4	3	MG/KG		V	RFA	UPPER
MANGANESE	B200789	BH07890612	73 5	73 5	3	MG/KG		V	RFA	UPPER
MANGANESE	B200789	BH07892426	75 8	75 8	3	MG/KG		V	RFA	UPPER
MANGANESE	B200789	BH07891218	96 6	96 6	3	MG/KG		V	RFA	UPPER
MANGANESE	B200789	BH07891824	110	110	3	MG/KG		V	RFA	UPPER
MANGANESE	B200789	BH07890103	221	221	3 8	MG/KG			RFA	UPPER
MANGANESE	B400289	BH02890309	37	37	3	MG/KG		V	RFA	UPPER
MANGANESE	B400289	BH02890003	38	38	3	MG/KG		V	RFA	UPPER
MANGANESE	B400289	BH02890915	168	168	3	MG/KG		V	RFA	UPPER
MANGANESE	B400289	BH02891521	99 8	99 8	3 2	MG/KG			RFA	UPPER
MANGANESE	B400389	BH03892733	91	91	3	MG/KG		V	RFA	UPPER
MANGANESE	B400389	BH03890003	69 8	69 8	3	MG/KG		V	RFA	UPPER
MANGANESE	B400389	BH03890309	103	103	3	MG/KG		V	RFA	UPPER
MANGANESE	B400389	BH03892127	140	140	3	MG/KG		V	RFA	UPPER
MANGANESE	B400389	BH03893339	216	216	3	MG/KG		V	RFA	UPPER
MANGANESE	B400389	BH03890915	231	231	3	MG/KG		V	RFA	UPPER
MANGANESE	B400389	BH03891521	233	233	3	MG/KG		V	RFA	UPPER
MANGANESE	B400389	BH03894548	243	243	3 2	MG/KG			RFA	UPPER
MANGANESE	B400389	BH03893945	409	409	3	MG/KG		V	RFA	UPPER
MANGANESE	B400489	BH04890003	116 4	116 4	3	MG/KG		V	RFA	UPPER
MANGANESE	B400489	BH04890309	195	195	3	MG/KG		V	RFA	UPPER
MANGANESE	B400489	BH04890915	197	197	3	MG/KG		V	RFA	UPPER
MANGANESE	B400489	BH04892127	294	294	3	MG/KG		V	RFA	UPPER
MANGANESE	B400489	BH04891521	427	427	3	MG/KG		V	RFA	UPPER
MANGANESE	B400489	BH04894652	89 3	89 3	3 5	MG/KG		A	RFA	UPPER
MANGANESE	B400489	BH04894046	105	105	3 8	MG/KG		A	RFA	UPPER
MANGANESE	B400489	BH04893840	219	219	4 5	MG/KG		A	RFA	UPPER
MANGANESE	B400489	BH04893335	254	254	4 1	MG/KG		A	RFA	UPPER
MANGANESE	B400489	BH04895254	293	293	3 4	MG/KG		A	RFA	UPPER
MANGANESE	B400489	BH04893538	460	460	7 3	MG/KG		A	RFA	UPPER
MANGANESE	B400489	BH04892733	488	488	3 2	MG/KG			RFA	UPPER

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Table A 86 Subsurface Soil Background Radionuclide Data								
Analyte	Location	Sample	Result	Error	Units	Validation Qualifier	Geologic Unit	Flow Unit
AMERICIUM-241	B200589	BH05890003	-0 015	0 02	PCI/G		RFA	UPPER
AMERICIUM-241	B200589	BH05891317	0	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200589	BH05890308	0 01	0 03	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200589	BH05890913	0 01	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200589	BH05891723	0 01	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200589	BH05892325	0 01	0 03	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200589	BH05892530	0	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200589	BH05890003R	-0 01	0 02	PCI/G		RFA	UPPER
AMERICIUM-241	B200689	BH06890104	-0 01	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200689	BH06891824	-0 01	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200689	BH06892430	-0 01	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200689	BH06890410	0	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200689	BH06891016	0	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200689	BH06891618	0	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200789	BH07890103	0	0 01	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200789	BH07890306	0	0 01	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200789	BH07890612	0	0 04	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200789	BH07891218	0	0 01	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200789	BH07891824	0	0 01	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200789	BH07892426	0	0 01	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200789	BH07890003	-0 01	0 01	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200889	BH08890106	-0 01	0 01	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200889	BH08890608	0	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200889	BH08890814	0	0 01	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200889	BH08891420	0	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200889	BH08892022	0	0 02	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200889	BH08890003	-0 01	0 01	PCI/G	N	RFA	UPPER
AMERICIUM-241	B200989	BH09890003	0	0 02	PCI/G	N	RFA	UPPER
PLUTONIUM-239,240	B201089	BH10890106	0 01	0 02	PCI/G		COL	UPPER
LUTONIUM-239,240	B201089	BH10890003	0	0 02	PCI/G		COL	UPPER
LUTONIUM-239,240	B201189	BH11890309	-0 005	0 01	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201189	BH11891521	0	0 01	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201189	BH11890003	0 01	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201189	BH11890915	0 01	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201189	BH11892733	0 01	0 01	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201189	BH11892127	0 02	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201289	BH12890003	0	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201289	BH12890307	0 02	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201289	BH12890915	0 005	0 01	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201289	BH12891521	0	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201489	BH13890307	0	0 01	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201489	BH13890003	0 01	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201589	BH14890307	0	0 01	PCI/G		COL	UPPER
PLUTONIUM-239,240	B201589	BH14890003	0 01	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B301889	BH15890309	0	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B301889	BH15891521	0	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B301889	BH15890915	0 01	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B301889	BH15890003	0 02	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B302089	BH17890003	0	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B302089	BH17890306	0	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B401989	BH16890003	0	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B401989	BH16890309	0	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B401989	BH16890915	0	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B401989	BH16891519	0 01	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B402189	BH18890003	0 02	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B402189	BH18890307	0 02	0 02	PCI/G		COL	UPPER
PLUTONIUM-239,240	B200589	BH05891723	0 005	0 02	PCI/G		RFA	UPPER
LUTONIUM-239,240	B200589	BH05890003	0	0 02	PCI/G		RFA	UPPER
LUTONIUM-239,240	B200589	BH05890913	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200589	BH05891317	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200589	BH05890308	0 01	0 03	PCI/G		RFA	UPPER

Table A 86 Subsurface Soil Background Radionuclide Data

Analyte	Location	Sample	Result	Error	Units	Validation Qualifier	Geologic Unit	Flow Unit
PLUTONIUM-239,240	B200589	BH05892325	0 01	0 03	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200589	BH05892530	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200589	BH05890003R	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200689	BH06890104	-0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200689	BH06890410	-0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200689	BH06891618	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200689	BH06892430	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200689	BH06891016	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200689	BH06891824	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200689	BH06890003	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200789	BH07891824	-0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200789	BH07890306	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200789	BH07892426	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200789	BH07890103	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200789	BH07890612	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200789	BH07891218	0 02	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200789	BH07890003	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200889	BH08891420	-0 005	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200889	BH08890608	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200889	BH08890814	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200889	BH08890106	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200889	BH08892022	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200889	BH08890003	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200989	BH09891620	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200989	BH09891016	0	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200989	BH09890104	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200989	BH09890410	0 01	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B200989	BH09890003	0 02	0 02	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400289	BH02890309	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400289	BH02890915	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400289	BH02890003	0 01	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400289	BH02892130	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400289	BH02891521	0 01	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400289	BH02893036	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400289	BH02893642	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400289	BH02894248	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400389	BH03892733	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400389	BH03890003	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400389	BH03890309	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400389	BH03890915	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400389	BH03891521	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400389	BH03892127	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400389	BH03893339	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400389	BH03893945	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400389	BH03894548	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04890003	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04890309	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04890915	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04891521	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04892127	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04892733	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04893335	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04893538	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04893840	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04894046	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04894652	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B400489	BH04895254	0	0 01	PCI/G		RFA	UPPER
PLUTONIUM-239,240	B405189	BH01890915	-0 01	0 02	PCI/G		WCS	UPPER
PLUTONIUM-239,240	B405189	BH01890309	0	0 02	PCI/G		WCS	UPPER
PLUTONIUM-239,240	B405189	BH01891521	0	0 02	PCI/G		WCS	UPPER
PLUTONIUM-239,240	B405189	BH01892127	0	0 02	PCI/G		WCS	UPPER

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Analyte	Location	Sample	Result	Error	Units	Validation Qualifier	Geologic Unit	Flow Unit
PLUTONIUM-239,240	B405189	BH01890003	0 03	0 03	PCI/G		WCS	UPPER
PLUTONIUM-239,240	B405189	BH01893638	0	0 01	PCI/G		WCS	UPPER
PLUTONIUM-239,240	B405189	BH01893036	0 01	0 02	PCI/G		WCS	UPPER
PLUTONIUM-239,240	B405189	BH01893844	0 01	0 01	PCI/G		WCS	UPPER
PLUTONIUM-239,240	B405189	BH01894448	0 01	0 01	PCI/G		WCS	UPPER
URANIUM-233,234	B201089	BH10890106	0 55	0 1	PCI/G		COL	UPPER
URANIUM-233,234	B201089	BH10890003	0 5	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B201189	BH11890915	0 5	0 1	PCI/G		COL	UPPER
URANIUM-233,234	B201189	BH11890309	0 6	0 1	PCI/G		COL	UPPER
URANIUM-233,234	B201189	BH11891521	0 6	0 1	PCI/G		COL	UPPER
URANIUM-233,234	B201189	BH11890003	0 8	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B201189	BH11892127	1	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B201189	BH11892733	1 2	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B201289	BH12890307	0 5	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B201289	BH12890003	0 7	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B201289	BH12890915	0 75	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B201289	BH12891521	1 2	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B201489	BH13890003	0 5	0 1	PCI/G		COL	UPPER
URANIUM-233,234	B201489	BH13890307	0 9	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B201589	BH14890003	0 4	0 1	PCI/G		COL	UPPER
URANIUM-233,234	B201589	BH14890307	0 7	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B301889	BH15890309	0 9	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B301889	BH15891521	1	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B301889	BH15890003	1 1	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B301889	BH15890915	8 9	0 3	PCI/G		COL	UPPER
URANIUM-233,234	B302089	BH17890306	1 1	0 3	PCI/G		COL	UPPER
URANIUM-233,234	B302089	BH17890003	2 6	0 5	PCI/G		COL	UPPER
URANIUM-233,234	B401989	BH16890915	0 8	0 2	PCI/G		COL	UPPER
URANIUM-233,234	B401989	BH16890003	0 9	0 3	PCI/G		COL	UPPER
URANIUM-233,234	B401989	BH16891519	0 9	0 3	PCI/G		COL	UPPER
URANIUM-233,234	B401989	BH16890309	1 1	0 3	PCI/G		COL	UPPER
URANIUM-233,234	B402189	BH18890003	0 5	0 2	PCI/G	N	COL	UPPER
URANIUM-233,234	B402189	BH18890307	0 7	0 3	PCI/G	N	COL	UPPER
URANIUM-233,234	B200589	BH05890003	0 55	0 1	PCI/G		RFA	UPPER
URANIUM-233,234	B200589	BH05891723	0 5	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200589	BH05890308	0 7	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200589	BH05890913	0 7	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200589	BH05891317	0 8	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200589	BH05892325	0 8	0 2	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200589	BH05892530	0 7	0 2	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200589	BH05890003R	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B200689	BH06890410	0 5	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200689	BH06891016	0 5	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200689	BH06892430	0 6	0 2	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200689	BH06890104	0 7	0 2	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200689	BH06891618	0 7	0 2	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200689	BH06891824	0 8	0 2	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200689	BH06890003	0 3	0 1	PCI/G		RFA	UPPER
URANIUM-233,234	B200789	BH07890612	0 4	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200789	BH07892426	0 4	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200789	BH07890306	0 5	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200789	BH07891218	0 5	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200789	BH07891824	0 5	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200789	BH07890103	0 6	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200789	BH07890003	0 8	0 2	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200889	BH08890608	0 35	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200889	BH08891420	0 3	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200889	BH08892022	0 3	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200889	BH08890106	0 4	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200889	BH08890814	0 5	0 1	PCI/G	N	RFA	UPPER
URANIUM-233,234	B200889	BH08890003	0 7	0 2	PCI/G	N	RFA	UPPER

Table A 86 Subsurface Soil Background Radionuclide Data								
Analyte	Location	Sample	Result	Error	Units	Validation Qualifier	Geologic Unit	Flow Unit
URANIUM-233,234	B200989	BH09890104	0 4	0 1	PCI/G		RFA	UPPER
URANIUM-233,234	B200989	BH09891016	0 5	0 1	PCI/G		RFA	UPPER
URANIUM-233,234	B200989	BH09891620	0 7	0 1	PCI/G		RFA	UPPER
URANIUM-233,234	B200989	BH09890410	3 4	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B200989	BH09890003	2 4	0 3	PCI/G	N	RFA	UPPER
URANIUM-233,234	B400289	BH02890003	0 4	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400289	BH02890915	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400289	BH02890309	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400289	BH02892130	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400289	BH02891521	0 8	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400289	BH02893036	0 2	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400289	BH02893642	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400289	BH02894248	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400389	BH03892733	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400389	BH03891521	0 5	0 1	PCI/G		RFA	UPPER
URANIUM-233,234	B400389	BH03892127	0 4	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400389	BH03890003	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400389	BH03890915	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400389	BH03893339	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400389	BH03890309	1 1	0 3	PCI/G		RFA	UPPER
URANIUM-233,234	B400389	BH03893945	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400389	BH03894548	1	0 3	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04890309	0 3	0 1	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04892127	0 4	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04890003	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04890915	0 5	0.2	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04891521	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04892733	0 4	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04894046	0 4	0 2	PCI/G		RFA	UPPER
JRANIUM-233,234	B400489	BH04894652	0 4	0 1	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04893840	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04893335	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04893538	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B400489	BH04895254	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-233,234	B405189	BH01891521	0 4	0 1	PCI/G	N	WCS	UPPER
URANIUM-233,234	B405189	BH01890309	0 5	0 1	PCI/G	N	WCS	UPPER
URANIUM-233,234	B405189	BH01892127	0 6	0 2	PCI/G	N	WCS	UPPER
URANIUM-233,234	B405189	BH01890915	0 7	0 2	PCI/G	N	WCS	UPPER
URANIUM-233,234	B405189	BH01890003	0 8	0.2	PCI/G	N	WCS	UPPER
URANIUM-233,234	B405189	BH01893638	0 5	0 2	PCI/G	N	WCS	UPPER
URANIUM-233,234	B405189	BH01893036	0 6	0 2	PCI/G	N	WCS	UPPER
URANIUM-233,234	B405189	BH01893844	0 6	0 1	PCI/G	N	WCS	UPPER
URANIUM-233,234	B405189	BH01894448	0 7	0 2	PCI/G	N	WCS	UPPER
URANIUM-235	B201089	BH10890106	0 05	0 1	PCI/G		COL	UPPER
URANIUM-235	B201089	BH10890003	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201189	BH11890309	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201189	BH11891521	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201189	BH11892733	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201189	BH11890003	0 1	0 1	PCI/G		COL	UPPER
URANIUM-235	B201189	BH11890915	0 1	0 1	PCI/G		COL	UPPER
URANIUM-235	B201189	BH11892127	0 1	0 1	PCI/G		COL	UPPER
URANIUM-235	B201289	BH12890003	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201289	BH12890307	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201289	BH12890915	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201289	BH12891521	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201489	BH13890003	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201489	BH13890307	0 1	0 1	PCI/G		COL	UPPER
URANIUM-235	B201589	BH14890307	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B201589	BH14890003	0 1	0 1	PCI/G		COL	UPPER
URANIUM-235	B301889	BH15890915	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B301889	BH15890003	0 1	0 1	PCI/G		COL	UPPER

Table A 86 Subsurface Soil Background Radionuclide Data								
Analyte	Location	Sample	Result	Error	Units	Validation Qualifier	Geologic Unit	[illegible] Unit
URANIUM-235	B301889	BH15891521	0 1	0 1	PCI/G		COL	UPPER
URANIUM-235	B301889	BH15890309	0 2	0 1	PCI/G		COL	UPPER
URANIUM-235	B302089	BH17890306	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B302089	BH17890003	0 1	0 1	PCI/G		COL	UPPER
URANIUM-235	B401989	BH16890003	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B401989	BH16890309	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B401989	BH16890915	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B401989	BH16891519	0	0 1	PCI/G		COL	UPPER
URANIUM-235	B402189	BH18890003	0 1	0 1	PCI/G	N	COL	UPPER
URANIUM-235	B402189	BH18890307	0 1	0 1	PCI/G	N	COL	UPPER
URANIUM-235	B200589	BH05890003	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B200589	BH05890308	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200589	BH05890913	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200589	BH05891317	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200589	BH05891723	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200589	BH05892325	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200589	BH05892530	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200589	BH05890003R	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B200689	BH06890104	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200689	BH06890410	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200689	BH06891016	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200689	BH06891618	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200689	BH06891824	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200689	BH06892430	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200689	BH06890003	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B200789	BH07890103	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200789	BH07890306	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200789	BH07890612	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200789	BH07891218	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200789	BH07891824	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200789	BH07892426	0 1	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200789	BH07890003	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200889	BH08890106	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200889	BH08890608	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200889	BH08890814	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200889	BH08891420	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200889	BH08892022	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200889	BH08890003	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B200989	BH09890104	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B200989	BH09890410	0 1	0 1	PCI/G		RFA	UPPER
URANIUM-235	B200989	BH09891016	0 1	0 1	PCI/G		RFA	UPPER
URANIUM-235	B200989	BH09891620	0 1	0 1	PCI/G		RFA	UPPER
URANIUM-235	B200989	BH09890003	0	0 1	PCI/G	N	RFA	UPPER
URANIUM-235	B400289	BH02890003	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400289	BH02890309	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400289	BH02890915	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400289	BH02891521	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400289	BH02892130	0 1	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400289	BH02893036	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400289	BH02893642	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400289	BH02894248	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400389	BH03892733	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400389	BH03890003	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400389	BH03890915	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400389	BH03891521	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400389	BH03892127	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400389	BH03893339	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400389	BH03890309	0 1	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400389	BH03893945	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400389	BH03894548	0 1	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04890003	0	0 1	PCI/G		RFA	UPPER

Table A.86 Subsurface Soil Background Radionuclide Data								
Analyte	Location	Sample	Result	Error	Unit	Validation Qualifier	Geologic Unit	Flow Unit
URANIUM-235	B400489	BH04890309	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04890915	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04891521	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04892127	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04892733	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04893335	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04893538	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04893840	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04894046	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04894652	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B400489	BH04895254	0	0 1	PCI/G		RFA	UPPER
URANIUM-235	B405189	BH01890003	0	0 1	PCI/G	N	WCS	UPPER
URANIUM-235	B405189	BH01890309	0	0 1	PCI/G	N	WCS	UPPER
URANIUM-235	B405189	BH01890915	0	0 1	PCI/G	N	WCS	UPPER
URANIUM-235	B405189	BH01891521	0	0 1	PCI/G	N	WCS	UPPER
URANIUM-235	B405189	BH01892127	0	0 1	PCI/G	N	WCS	UPPER
URANIUM-235	B405189	BH01893638	0	0 1	PCI/G	N	WCS	UPPER
URANIUM-235	B405189	BH01893844	0	0 1	PCI/G	N	WCS	UPPER
URANIUM-235	B405189	BH01894448	0	0 1	PCI/G	N	WCS	UPPER
URANIUM-235	B405189	BH01893036	0 2	0 1	PCI/G	N	WCS	UPPER
URANIUM-238	B201089	BH10890106	0 6	0 1	PCI/G		COL	UPPER
URANIUM-238	B201089	BH10890003	0 4	0 2	PCI/G		COL	UPPER
URANIUM-238	B201189	BH11890309	0 9	0 2	PCI/G		COL	UPPER
URANIUM-238	B201189	BH11890915	0 7	0 2	PCI/G		COL	UPPER
URANIUM-238	B201189	BH11890003	0 8	0 2	PCI/G		COL	UPPER
URANIUM-238	B201189	BH11891521	0 9	0 2	PCI/G		COL	UPPER
URANIUM-238	B201189	BH11892127	1 2	0 3	PCI/G		COL	UPPER
URANIUM-238	B201189	BH11892733	1 3	0 2	PCI/G		COL	UPPER
URANIUM-238	B201289	BH12890003	0 9	0 2	PCI/G		COL	UPPER
URANIUM-238	B201289	BH12890307	1	0 3	PCI/G		COL	UPPER
URANIUM-238	B201289	BH12890915	1 1	0 2	PCI/G		COL	UPPER
URANIUM-238	B201289	BH12891521	1 2	0 2	PCI/G		COL	UPPER
URANIUM-238	B201489	BH13890003	0 7	0 2	PCI/G		COL	UPPER
URANIUM-238	B201489	BH13890307	0 8	0 2	PCI/G		COL	UPPER
URANIUM-238	B201589	BH14890003	0 7	0 2	PCI/G		COL	UPPER
URANIUM-238	B201589	BH14890307	0 9	0 2	PCI/G		COL	UPPER
URANIUM-238	B301889	BH15891521	0 5	0 1	PCI/G		COL	UPPER
URANIUM-238	B301889	BH15890915	0 8	0 3	PCI/G		COL	UPPER
URANIUM-238	B301889	BH15890309	1	0 2	PCI/G		COL	UPPER
URANIUM-238	B301889	BH15890003	1 1	0 2	PCI/G		COL	UPPER
URANIUM-238	B302089	BH17890306	1 15	0 3	PCI/G		COL	UPPER
URANIUM-238	B302089	BH17890003	2 3	0 4	PCI/G		COL	UPPER
URANIUM-238	B401989	BH16890309	0 8	0 2	PCI/G		COL	UPPER
URANIUM-238	B401989	BH16890915	0 9	0.2	PCI/G		COL	UPPER
URANIUM-238	B401989	BH16891519	0 9	0 3	PCI/G		COL	UPPER
URANIUM-238	B401989	BH16890003	1 1	0 3	PCI/G		COL	UPPER
URANIUM-238	B402189	BH18890003	0 7	0 2	PCI/G	N	COL	UPPER
URANIUM-238	B402189	BH18890307	1 1	0 3	PCI/G	N	COL	UPPER
URANIUM-238	B200589	BH05891723	0 5	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200589	BH05890003	0 6	0 1	PCI/G		RFA	UPPER
URANIUM-238	B200589	BH05892325	0 6	0 2	PCI/G	N	RFA	UPPER
URANIUM-238	B200589	BH05890308	0 8	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200589	BH05890913	0 8	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200589	BH05891317	0 9	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200589	BH05892530	0 6	0 2	PCI/G	N	RFA	UPPER
URANIUM-238	B200589	BH05890003R	0 9	0 2	PCI/G		RFA	UPPER
URANIUM-238	B200689	BH06890410	0 3	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200689	BH06891016	0 6	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200689	BH06891824	0 7	0 2	PCI/G	N	RFA	UPPER
URANIUM-238	B200689	BH06892430	0 7	0 2	PCI/G	N	RFA	UPPER
URANIUM-238	B200689	BH06890104	0 8	0 2	PCI/G	N	RFA	UPPER

Table A.86 Subsurface Soil Background Radionuclide Data								
Analyte	Location	Sample	Result	Error	Units	Validation Qualifier	Geologic Unit	Flow Unit
URANIUM-238	B200689	BH06891618	0 9	0 2	PCI/G	N	RFA	UPPER
URANIUM-238	B200689	BH06890003	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-238	B200789	BH07891218	0 3	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200789	BH07890612	0 4	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200789	BH07892426	0 4	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200789	BH07890103	0 6	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200789	BH07890306	0 6	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200789	BH07891824	0 7	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200789	BH07890003	0 6	0 2	PCI/G	N	RFA	UPPER
URANIUM-238	B200889	BH08891420	0 35	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200889	BH08890106	0 4	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200889	BH08890608	0 4	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200889	BH08892022	0 4	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200889	BH08890814	0 5	0 1	PCI/G	N	RFA	UPPER
URANIUM-238	B200889	BH08890003	0 6	0 2	PCI/G	N	RFA	UPPER
URANIUM-238	B200989	BH09890104	0 4	0 1	PCI/G		RFA	UPPER
URANIUM-238	B200989	BH09891016	0 5	0 1	PCI/G		RFA	UPPER
URANIUM-238	B200989	BH09891620	0 6	0 1	PCI/G		RFA	UPPER
URANIUM-238	B200989	BH09890410	3 2	0 2	PCI/G		RFA	UPPER
URANIUM-238	B200989	BH09890003	0 7	0 2	PCI/G	N	RFA	UPPER
URANIUM-238	B400289	BH02890003	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400289	BH02890915	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400289	BH02890309	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400289	BH02892130	0 85	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400289	BH02891521	0 8	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400289	BH02893036	0 3	0 1	PCI/G		RFA	UPPER
URANIUM-238	B400289	BH02893642	0 4	0 1	PCI/G		RFA	UPPER
URANIUM-238	B400289	BH02894248	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400389	BH03892733	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400389	BH03890003	0 65	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400389	BH03891521	0 5	0 1	PCI/G		RFA	UPPER
URANIUM-238	B400389	BH03892127	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400389	BH03893339	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400389	BH03890309	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400389	BH03890915	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400389	BH03893945	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400389	BH03894548	1 1	0 3	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04890309	0 4	0 1	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04891521	0 4	0 1	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04890003	0 5	0 1	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04890915	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04892127	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04894046	0 2	0 1	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04893840	0 5	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04892733	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04894652	0 6	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04893538	0 7	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04895254	0 9	0 2	PCI/G		RFA	UPPER
URANIUM-238	B400489	BH04893335	1	0 2	PCI/G		RFA	UPPER
URANIUM-238	B405189	BH01890003	0 6	0 2	PCI/G	N	WCS	UPPER
URANIUM-238	B405189	BH01890309	0 6	0 1	PCI/G	N	WCS	UPPER
URANIUM-238	B405189	BH01891521	0 6	0 1	PCI/G	N	WCS	UPPER
URANIUM-238	B405189	BH01892127	0 8	0 2	PCI/G	N	WCS	UPPER
URANIUM-238	B405189	BH01890915	0 9	0 2	PCI/G	N	WCS	UPPER
URANIUM-238	B405189	BH01893638	0 7	0 2	PCI/G	N	WCS	UPPER
URANIUM-238	B405189	BH01894448	0 7	0 2	PCI/G	N	WCS	UPPER
URANIUM-238	B405189	BH01893036	0 8	0 2	PCI/G	N	WCS	UPPER
URANIUM-238	B405189	BH01893844	0 9	0 2	PCI/G	N	WCS	UPPER

Table A.87 Surface Soil Background Data Summary
(mg/kg inorganic, pCi/g radionuclides)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALUMINUM	7429-90-5	20	100	4050	17100	10202	3256
ARSENIC	7440-38-2	20	100	2 3	9 6	6 1	2
CADMIUM	7440-43-9	20	61	0 295	2 3	0 71	0 46
CHROMIUM	7440-47-3	20	100	5 5	16 9	11 24	2 78
MANGANESE	7439-96-5	20	100	129	357	237	63 9
AMERICIUM-241	14596-10-2	50	100	0 001	0 025	0 011	0 006
PLUTONIUM-239/240	10-12-8	50	100	0 017	0 076	0 039	0 015
URANIUM-233,-234	11-08-5	20	100	0 66	3 1	1 10	5 78
URANIUM-235	15117-96-1	20	100	0 033	0 11	0 54	0 02
URANIUM-238	7440-61-1	20	100	0 74	2 6	1 09	0 46

Table A.88 Subsurface Soil Background Data Summary
(mg/kg inorganics or pCi/g radionuclides)

[illegible]	[illegible]	[illegible]	[illegible]	Minimum	Maximum	Mean	Standard Deviation
ALUMINUM	7429-90-5	98	99	279	102000	12713	11335
ARSENIC	7440-38-2	99	71	0 27	41 8	3 65	4 42
BARIUM	7440-39-3	99	89	12 9	777	96 1	96 6
CADMIUM	7440-43-9	99	7	0 08	1 5	0 58	0 30
CHROMIUM	7440-47-3	99	85	4 1	176	19 6	24 3
IRON	7439-89-6	99	100	1300	132000	14532	13257
MANGANESE	7439-96-5	99	100	37	3330	218	342
AMERICIUM-241	14596-10-2	28	100	-0 02	0 01	0	0 01
PLUTONIUM-239/240	10-12-8	83	100	-0 01	0 03	0	0 01
URANIUM-233/234	11-08-5	99	100	0 2	8 9	0 78	0 93
URANIUM-235	15117-96-1	99	100	0	0 2	0 02	0 05
URANIUM-238	7440-61-1	99	100	0 2	3 2	0 73	0 38

C.1 Appendix C Table of Contents

Spreadsheets Used to Calculate Human Health Risk and Hazards for the Solar Ponds Risk Assessment		
Step	**Worksheet**	**Description**
1	"2002 Toxicity"	Presents toxicity factors used in the calculations
2	"U Conversion"	Converts concentrations of uranium isotopes from pCi/g to mg/kg
3	"Exp pt conc"	Presents chemicals of concern for the Solar Evaporation Ponds (IHSS 101) risk assessment including number of samples, percent detection, minimum, maximum, mean, and 95% UCL
4	"Equations WLRW"	Presents equations used in calculations
5	"WLRW Surface Intakes"	Presents factors used to calculate chemical intakes for a wildlife refuge worker from surface soil exposures, calculates intakes and presents the results
6	"WLRW Surface Soil Risk"	Presents factors used to calculate human health risks and hazards to a wildlife refuge worker from surface soil exposures, calculates risks and hazards and presents the results.
7	"WLRW Subsurface Intakes"	Presents factors used to calculate chemical intakes for a wildlife refuge worker from subsurface soil exposures, calculates intakes and presents the results
8	"WLRW Subsurface Soil Risk"	Presents factors used to calculate human health risks and hazards to a wildlife refuge worker from subsurface soil exposures, calculates risks and hazards and presents the results
9	"% Risk by COC"	Presents the percent of the total risk due to each COC by exposure pathway and media
10	"Summary"	Summarizes results of the assessment

C 2 Toxicity Factors Used in the SEP Risk Assessment

Toxicity Factors															
[illegible]															
Cadmium	7440-43-9	0 001	1 00E-03	I	2.50E-05	–		5 70E-05	E			6.30E+00	I		
Chromium[2]	7440-47-3	0 001	3 00E-03	I	7 50E-05	–		3 00E-05	I			4 10E+01	H		
[illegible]															
Am-241	14596-10-2					1 04E 10	E	1.34 E 10	E	9 1E-11	R	2.78E-08	E	2.76E-08	E
Pu-239	15117-48-3					1 35E-10	E	1 74E 10	E	1.21E 10	R	3.33E-08	E	2.00E 10	E
U-234	13966-29-5	0 001	3 00E-03	I		7 07E 11	E	9.55E-11	E	5 11E-11	R	1 14E-08	E	2.62E 10	E
U-235	15117-96-1	0 001	3 00E-03	I		6 96E 11	E	9 44E 11	E	4 92E 11	R	1 01E-08	E	5 18E-07	E
U-238	7440-61 1	0 001	3 00E-03	I		6 4E-11	E	8 66E 11	E	4 66E 11	R	9 35E-09	E	4 99E 11	E

Notes

1 Values for DAF (fraction absorbed through skin) are from EPA, 2001 Values for chromium are default values based on the value for cadmium

2. Assessed as chromium (VI)

I = IRIS

E = NCEA provisional value

H = HEAST

R = RSALS PPRG Tables

References

IRIS 2001 = U S Environmental Protection Agency 1998 Integrated Risk Information System On-line database Office of Research and Development, Cincinnati OH. June

HEAST 1997 = U S Environmental Protection Agency 2001 Health Effects Assessment Summary Tables

HEAST 2001 = U S Environmental Protection Agency 2001 Health Effects Assessment Summary Tables, Radionuclide Table

EPA, Office of Radiation and Indoor Air (ORIA), April

EPA 2001 = U S Environmental Protection Agency 2001 Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim EPA/540/R/99/oo5 OSWER 9285 7-02EP PB99-963312 September

C.3 SEP Uranium Conversion fron Actıvity to Mass

Assumptions:

Specıfic Actıvıty				
U-238	3 35E-07	Cı/g	1 24E-08	TBq/g
U-235	2 16E-06	Cı/g	7 99E-08	TBq/g
U-234	6 24E-03	Cı/g	2 31E-04	TBq/g

Assumed U-234 Accounts for all U-233/U-234 Actıvıty

Calculations: To convert from pCi/g to mg/kg

g of matenal per kg
1000

Surface Soil COCs				
	pCı/g	Cı/kg	g/kg	mg/kg
U-233/U-234	6 53	6 53E-09	1 05E-06	1 05E-03
U-235	0 289	2 89E-10	1 34E-04	1 34E-01
U-238	3.77	3 77E-09	1 13E-02	1 13E+01
Pond Liner Material COCs				
U-235	0 27	2 70E-10	1 25E-04	1 25E-01
U-238	2 68	2 68E-09	8 00E-03	8 00E+00
Subsurface Soil COCs				
U-233/U-234	3 65	3 65E-09	5 84E-07	5 84E-04
U-235	0 153	1 53E-10	7 09E-05	7 09E-02
U-238	2.14	2 14E-09	9 88E-04	9 88E-01

C 4 Exposure point Concentrations Used in the SEP Risk Assessment

[illegible]							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		%	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg or pCi/g	mg/kg	pCi/g
[illegible]							
Cadmium	73	59	0 135	382	20 1	**38.1**	
Chromium	73	97	0 47	120	20 3	**24.8**	
Amencum-241	69	100%	0 011	130	9 11		**34.2**
Plutonium-239/240	60	100%	0 013	56	4 19		**16.5**
Uranium-234	71	100%	0 51	63 4	4 16	**0.001**	**6 5**
Uranium-235	71	76%	-0 008	2 3	0 186	**0 13**	**0 29**
Uranium-238	72	100%	0 31	27	2 73	**11 3**	**3 77**
[illegible]							
Chromium	15	100%	5 7	**37.5**	15 4		21.3
Amencium-241	15	60%	0 003	**8 19**	1 70		10589
Uranium-235	15	67%	0 018	**0.27**	0 13	**0 13** a	0 21
Uranium-238	15	100%	0 52	**2.68**	1 40	**8 00** a	1 79
[illegible]							
Cadmium	97	30%	0 09	547	1 1	**9 6**	
Amencum-241	95	86%	-0 04	6 1	0 487		**0 69**
Plutonium-239/240	98	83%	-0 06	19 78	0 639		**1.20**
Uranium-234	118	99%	0	21	2 92	**0.0006**	**3.65**
Uranium-235	99	72%	0	0 87	0 13	**0 071**	**0.15**
Uranium-238	118	97%	0 1	11 46	1 40	**0 99**	**2.14**

(1) The bolded values were used as the exposure point concentratıons for risk calculations 95UCL values were used for surfa and subsurface soils Maximum values were used for the lıner per agreement with EPA and CDPHE

(2) The 95UCL concetrations for mineral uranium was calculated from the 95UCL for the radionuclıde

(a) The value of 0 13 ıs for the maximum concentration of U-235 in the liner

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Wildlife Refuge Worker Scenario[1]			
Risk Equations - Radionuclides			
Inhalation Risk = CSs x IR_h x ET x ETo x EF x ED x AWF x AUF x (1/PEF) x 1000 g/kg x SFi			
Ingestion Risk = CSs x IR_s x EF x ED x AWF x AUF x 0 001 g/mg x SFo			
External Radiation Risk = CSs x ED x EF/365 x ET/24 x AWF x AUF x SFe x (1-Se)			
Risk Equations - [illegible]			
Inhalation Risk = [(CSs x IR_h x ET x ETo x EF x ED x AWF x AUF x (1/PEF))/(BW x ATc)] x SFinh			
Ingestion Risk = [(CSs x IR_s x EF x ED x AWF x AUF x 0 000001 mg/kg)/(BW*ATc)] x SFo			
Dermal Risk = [(CSs x EF x ED x AWF x AUF x EV x SA_s x AF_d x DAF x 0 000001 mg/kg)/(BW x ATc)] x SFo			
Noncarcinogenic Hazard Quotient Equations - [illegible]			
Inhalation HQ = (CSs x IR_h x ET x EF x ED x ETo x AWF x AUF x (1/PEF))/(BW x ATn x RfDi)			
Ingestion HQ =(CSs x IR_s x ED x EF x AWF x AUF x 0 000001 mg/kg)/(BW x ATn x RfDo)			
Dermal HQ = (CSs x EF x ED x AWF x AUF x EV x SA_s x AF_d x DAF x 0 000001 mg/kg)/(BW x ATn x RfDo)			
CSs	Concentration in soil	mg/kg	
IR_h	Hourly inhalation rate	m3/hr	
IR_s	Soil ingestion rate	mg/day	
ET	Exposure time	hr/day	
EF	Exposure frequency	day/yr	
ED	Exposure duration	yr	
ETo	Exposure time fraction, outdoors	unitless	Set to 1
EV	Events per day	ev/d	
AWF	Area Weighting Factor	unitless	
AUF	Area Use Factor	unitless	Set to 1
EF/365	Gamma exposure factor (annual)	unitless	
ET/24	Gamma exposure factor (daily)	unitless	
PEF	Site-specific PEF based on ML	m3/kg	
SA_s	Surface Area of Exposed Skin - Soil	cm^2	
AF_d	Dermal Adherance Factor	mg/cm^2-ev	
DAF	Dermal Absorption Fraction	unitless	
SFinh	Inhalation slope factor	(2)	
SFo	Oral slope factor	(2)	
SFe	External radiation slope factor	(2)	
BW	Body Weight	kg	
ATc	Carcinogenic Averaging Time	days	
ATn	Noncarcinogenic Averaging Time	days	
RfDi	Inhalation reference dose	(mg/kg-day)	
RfDo	Inhalation reference dose	(mg/kg-day)	
ACF	Area correction factor	unitless	
(1 - Se)	Gamma shielding factor	unitless	Set to 1
1 Based on the wildlife refuge worker scenario developed by the RSALS Working Group			
2 Slope factors for inorganic and organic COCs are in units of $(mg/kgday)^{-1}$ Slope factors for radionuclides inhalation and ingestion exposures are in units of risk/pCi Slope factors for External Exposures are in units of risk/yr per pCi/g			

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C 6 Calculation Sheet for Surface Soil and Liner Material Intakes

Chemical Intakes for the Wildlife Refuge Worker from Surface Soil and Liner Material at the Solar Ponds				
Wildlife Refuge Worker Exposure Variable	Acronym	Units	Point Estimate	Sources
Body Weight	BW	kg	70	EPA default
Exposure time	ET	hr/day	4	RSALS Task 3
Exposure time fraction, outdoors	ETo	unitless	1	No Building
Area Use Factor	AUF	unitless	1	AOC area/EU area
Exposure frequency	EF	day/yr	230	EPA default of 250 days minus 20 days for subsurface activities
Exposure duration	ED	yr	18.7	RSALS Task 3
Events per day	EV	er/d	1	Unit correction
Carcinogenic Averaging Time	ATc	days	25550	70 yr x 365 days/yr
Noncarcinogenic Averaging Time	ATn	days	6826	18.7 yr x 365 days/yr
Hourly inhalation rate	IR_h	m3/hr	1 3	RSALS Task 3
Mass loading	ML	kg/m3	2 12E-08	50th percentile of RSALS distibution
Site-specific PEF based on ML	PEF	m3/kg	47169811	1/ML
Soil ingestion rate	IR_s	mg/day	100	EPA default
Dermal Adherance Factor	AF_d	mg/cm2	0 1	EPA, 2001
Surface Area of Exposed Skin Soil	SA_s	cm2	4260	EPA, 1997
Area Weighting Factor-Pond liners	AWFpl	unitless	0.2	SEP area/AOC area
Area Weighting Factor-Soils	AWFs	unitless	0.8	Surface soil area/AOC area
Gamma exposure factor (annual)	EF/365	unitless	0 63	EF/365
Gamma exposure factor (daily)	ET/24	unitless	0 17	ET/24 per Rags Part B (EPA, 1993)
Gamma shielding factor	(1 Se)	unitless	1	EPA, 1993

Chemical Intakes from Surface Soil and Pond Liners for the Wildlife Refuge Worker by Exposure Pathway					
COC	Carcinogenic Intakes from Surface Soil				Total Intake
	Inhalation	Ingestion	Dermal	External	
	mg/kg-day				
Cadmium	8.07E-09	a	a	NA	8.1E-09
Chromium	5.27E-09	a	a	NA	5.3E-09
	Non-Carcinogenic Intakes from Surface Soil				
Cadmium	3.02E-08	2 74E-05	1 17E-04	NA	1 44E-04
Chromium	1 97E-08	1 79E-05	7 62E-05	NA	9 41E-05
Uranium 234	a	7.54E-10	3.21E-09	NA	3 97E-09
Uranium-235	a	9 62E-08	4 10E-07	NA	5 06E-07
Uranium-238	a	8.11E-06	3.46E-05	NA	4.27E-05
	Radiation Intakes from Surface Soil				
	pCi			yr/pCi/g	
Americium 241	1 30E+01	1 18E+04	NA	5.37E+01	NA
Plutonium-239/240	6.26E+00	5 68E+03	NA	2.59E+01	NA
Uranium-234	2.48E+00	2.25E+03	NA	1.03E+01	NA
Uranium 235	1 10E-01	9 94E+01	NA	4 54E-01	NA
Uranium-238	1 43E+00	1.30E+03	NA	5.93E+00	NA
	Carcinogenic Intakes from Pond Liner				
	mg/kg-day				
Chromium	7.95E-09	a	a	NA	8 0E-09
	Non-Carcinogenic Intakes from Pond Liner				
Chromium	2 98E-08	2 70E-05	1 15E-04	NA	1 42E-04
Uranium 235	a	2.25E-08	2.23E-11	NA	2.25E-08
Uranium-238	a	1 44E-06	1 43E-09	NA	1 44E-06
	Radiation Intakes from Pond Liner				
	pCi			yr/pCi/g	
Americium 241	7 76E-01	7 04E+02	NA	3.22E+00	NA
Uranium 235	2.56E-02	2.32E+01	NA	1 06E-01	NA
Uranium 238	2.54E-01	2 31E+02	NA	1 05E+00	NA

a No toxicity factor available for this exposure pathway
NA. Not applicable

C 7 SEP Risk Calculation Sheet for Surface Soil and Liner Materials

Human Health Assessment for Wildlife Refuge Worker Exposure to Surface Soil and Liner Materials at the Solar Ponds

Medium	Risk by AOC and Media				Total Risk
	Nonradiological				
	Inhalation	Ingestion	Dermal	External	
Surface Soil	2 67E-07	a	a	NA	2.7E-07
Liner	3 26E-07	a	a	NA	3.3E-07
Total Nonradiological Risk					6E-07
	Radiological				
Surface Soil	6 11E-07	1 94E-06	NA	1 72E-06	4.3E-06
Liner	2 42E-08	7 60E-08	NA	1 44E-07	2.4E-07
Total Radiological Risk					5E-06

Medium	Hazard Index by Media				Total HI
	Nonradiological				
	Inhalation	Ingestion	Dermal	External	
Surface Soil	0 001	0 03	0 006	NA	0 04
Liner	0 001	0 01	0 002	NA	0.01
Total Nonradiological Risk					0.05

Exposure Variable	Acronym	Units	Point Estimate	Sources
Body Weight	BW	kg	70	EPA default
Exposure time	ET	hr/day	4	RSALS Task
Exposure time fraction, outdoors	ETo	unitless	1	No Building
Area Use Factor	AUF	unitless	1	AOC area/EU area
Exposure frequency	EF	day/yr	` 230	EPA default. 250 d/yr 20 d/yr for subsurface exp
Exposure duration	ED	yr	18 7	RSALS Task 3
Events per day	EV	ev/d	1	Unit correction
Carcinogenic Averaging Time	ATc	days	25550	70 yr x 365 days/yr
Noncarcinogenic Averaging Time	ATn	days	6826	18 7 yr x 365 days/yr
Hourly inhalation rate	IR_h	m3/hr	1 3	RSALS Task 3
Mass loading	ML	kg/m3	2.12E-08	50th percentile of RSALS distibution
Site-specific PEF based on ML	PEF	m3/kg	47169811	1/ML
Soil ingestion rate	IR_s	mg/day	100	EPA default
Dermal Adherance Factor	AF_d	mg/cm2	0 1	EPA, 2001
Surface Area of Exposed Skin Soil	SA_s	cm2	4260	EPA, 1997
Area Weighting Factor-Pond liners	AWFpl	unitless	0.2	SEP area/AOC area
Area Weighting Factor Soils	AWFs	unitless	0 8	Surface soil area/AOC area
Gamma exposure factor (annual)	EF/365	unitless	0 63	EF/365
Gamma exposure factor (daily)	ET/24	unitless	0 17	ET/24 per Rags Part B (EPA, 1991)
Gamma shielding factor	(1 Se)	unitless	1	EPA, 1991 set to 1

Risks from Surface Soil and Liner for the Wildlife Refuge Worker by Exposure Pathway and COC

COC	Carcinogenic Risks from Surface Soil				Total Risk
	Inhalation	Ingestion	Dermal	External	
Cadmium	5 09E-08	a	a	NA	5 1E-08
Chromium	2.16E-07	a	a	NA	2.2E-07
	Non-Carcinogenic Hazard Quotients for Surface Soil				Hazard Index
Cadmium	0 0005	0 03	0 005	NA	0 03
Chromium	0 0007	0 006	0 001	NA	0 007
Uranium-234	a	0 0000003	0 000000001	NA	0 0000003
Uranium-235	a	0 00003	0 0000001	NA	0.00003
Uranium-238	a	0 003	0 00001	NA	0 003
	Radiological Risks from Surface Soil				Total Risk
Americium-241	3 60E-07	1 07E-06	NA	1 48E-06	2.9E-06
Plutonium-239/240	2 08E-07	6 87E-07	NA	5 18E-09	9 0E-07
Uranium-234	2 83E-08	1 15E-07	NA	2.59E-09	1 5E-07
Uranium-235	1 11E-09	4 89E-09	NA	2.35E-07	2 4E-07
Uranium-238	1 34E-08	6 05E-08	NA	2.96E-10	7 4E-08
	Carcinogenic Risks from Pond Liner				Total Risk
Chromium	3.26E-07	a	a	NA	3 3E-07
	Non-Carcinogenic Hazard Quotients for Pond Liners				Hazard Index
Chromium	0 001	0 009	0 002	NA	0 01
Uranium-235	a	0 00003	0 00000000003	NA	0 00003
Uranium-238	a	0 002	0 000000002	NA	0 002
	Radiological Risks from Pond Liners				Total Risk
Americium-241	2 16E-08	6 41E-08	NA	8 88E-08	1 7E-07
Uranium-235	2 59E 10	1 14E-09	NA	5 49E-08	5 6E-08
Uranium-238	2 38E-09	1 07E-08	NA	5 25E 11	1 3E-08

NA = Not applicable

EPA. 1993 Federal Guidance Report No 12. External Exposure to Radionuclides in Air Water and Soil EPA-402 R-93-081 September
EPA, 1997 Exposure Factors Handbook, Vol1 EPA/600/P 95/002Fc ORD Washington D C August.
EPA 2001 = U S Environmental Protection Agency 2001 Risk Assessment Guidance for Superfund Volume I Human Healthe Evaluation Manual (Part E Supplemental Guidance for Dermal Risk Assessment) Interim EPA/540/R/99/oo5 OSWER 9285 7-02EP PB99-963312, September

C 8 Calculation Sheet for Subsurface Soil Intakes

Chemical Intakes for Wildlife Refuge Worker Exposure to Subsurface Soil and Liner Material At Solar Ponds				
Wildlife Refuge Worker Exposure Variable	**Acronym**	**Units**	**Point Estimate**	**Sources**
Body Weight	BW	kg	70	EPA default
Exposure time outdoors	ET	hr/day	4	RSALS Task 3
Area Use Factor	AUF	unitless	1	AOC area/EU area
Exposure frequency	EF	day/yr	20	WLRWs in Rocky Mountain Arsenal (RMA) survey 1990
Exposure duration	ED	yr	18 7	RSALS Task 3
Events per day	EV	ev/d	1	Unit correction
Carcinogenic Averaging Time	ATc	days	25550	70 yr x 365 days/yr
Noncarcinogenic Averaging Time	ATn	days	6826	18 7 yr x 365 days/yr
Hourly inhalation rate	IR_h	m3/hr	1 3	RSALS Task 3
Mass loading	ML	kg/m3	2 12E-08	50th percentile of RSALS distibution
Site-specific PEF based on ML	PEF	m3/kg	47169811	1/ML
Soil ingestion rate	IR_s	mg/day	100	EPA default
Dermal Adherance Factor	AF_d	mg/cm2	0 1	EPA, 2001
Surface Area of Exposed Skin Soil	SA_s	cm2	4260	EPA, 1997
Gamma exposure factor (annual)	EF/365	unitless	0 05	EF/365
Gamma exposure factor (daily)	ET/24	unitless	0 17	ET/24 per Rags Part B (EPA, 1993)
Gamma shielding factor	(1 - Se)	unitless	1	EPA 1993

Chemical Intakes from Subsurface Soil for the Wildlife Refuge Worker by Exposure Pathway					
COC	**Carcinogenic Intakes from Subsurface Soil**				**Total**
	Inhalation	**Ingestion**	**Dermal**	**External**	**Intake**
	mg/kg-day				mg/kg-day
Cadmium	2.22E 10	a	a	NA	2.2E 10
	Non-Carcinogenic Intakes from Subsurface Soil				
Cadmium	8.31E-10	7.54E-07	3.21E-06	NA	3 97E-06
Uranium-234	a	4.57E-11	1 95E-10	NA	2 41E 10
Uranium-235	a	5.55E-09	2 36E-08	NA	2 92E-08
Uranium-238	a	7 74E-08	3 30E-07	NA	4 07E-07
	Radiation Intakes from Subsurface Soil				
	pCi			yr/pCi/g	pCi
Americium-241	2.85E-02	2.59E+01	NA	1 18E-01	2 6E+01
Plutonium-239/240	4 96E-02	4.50E+01	NA	2 06E-01	4 5E+01
Uranium-234	1.50E-01	1.36E+02	NA	6.23E-01	1 4E+02
Uranium-235	6 32E-03	5 73E+00	NA	2 62E-02	5 7E+00
Uranium 238	8 80E-02	7 98E+01		3 65E-01	8 0E+01

C 9 SEP Risk Calculation Sheet for Subsurface Soil

Human Health Assessment for Wildlife Refuge Worker Exposure to Subsurface Soil and Liner Material At Solar Ponds					
	Risk by Medium and Pathway				Total Risk by Medium
Medium	Nonradiological				
	Inhalation	Ingestion	Dermal	External	
Subsurface	1 40E-09	a	a	NA	1 4E-09
	Radiological				
Subsurface	5 05E-09	1.59E-08	NA	1 78E-08	3 9E-08
	Hazard Index by AOC and Media				Total HI by Medium
Medium	Nonradiological				
	Inhalation	Ingestion	Dermal	External	
Subsurface	0 00001	0 001	0 00012845	NA	0 001

Wildlife Refuge Worker Exposure Variable	Acronym	Units	Point Estimate	Sources
Body Weight	BW	kg	70	EPA default
Exposure time outdoors	ET	hr/day	4	RSALS Task 3
Area Use Factor	AUF	unitless	1	AOC area/EU area
Exposure frequency	EF	day/yr	20	WLRWs in RMA survey, 1990
Exposure duration	ED	yr	18 7	RSALS Task 3
Events per day	EV	er/d	1	Unit correction
Carcinogenic Averaging Time	ATc	days	25550	70 yr x 365 days/yr
Noncarcinogenic Averaging Time	ATn	days	6826	18 7 yr x 365 days/yr
Hourly inhalation rate	IR_h	m3/hr	1 3	RSALS Task 3
Mass loading	ML	kg/m3	2 12E-08	50th percentile of RSALS distibution
Site-specific PEF based on ML	PEF	m3/kg	47169811	1/ML
Soil ingestion rate	IR_s	mg/day	100	EPA default
Dermal Adherance Factor	AF_d	mg/cm2	0 1	EPA, 2001
Surface Area of Exposed Skin - Soil	SA_s	cm2	4260	EPA, 1997
Gamma exposure factor (annual)	EF/365	unitless	0 05	EF/365
Gamma exposure factor (daily)	ET/24	unitless	0 17	ET/24 per Rags Part B (EPA, 1991)
Gamma shielding factor	(1 - Se)	unitless	1	EPA, 1991

Risks from Wildlife Refuge Worker Exposure to Subsurface Soil and Liner Material At Solar Ponds					
	Carcinogenic Risks from Subsurface Soil				Total Risk
	Inhalation	Ingestion	Dermal	External	
Cadmium	1 40E-09	a	a	NA	1 40E-09
	Non-Carcinogenic Hazard Quotients for Suburface Soil				Hazard Index
Cadmium	0 00001	0 001	0 0001	NA	0 001
Uranium-234	a	0.00000002	0 0000000001	NA	0 00000002
Uranium-235	a	0 000002	0.00000000002	NA	0.000002
Uranium-238	a	0 00003	0 0000000003	NA	0 00003
	Radiological Risks from Suburface Soil				Total Risk
Americium-241	7 94E-10	2.36E-09	NA	3 26E-09	6 4E-09
Plutonium-239/240	1 65E-09	5 45E-09	NA	4 11E-11	7 1E-09
Uranium-234	1 71E-09	6 97E-09	NA	1 57E-10	8 8E-09
Uranium-235	6 38E-11	2 82E-10	NA	1 35E-08	1 4E-08
Uranium-238	8 23E-10	3 72E-09	NA	1 82E-11	4 6E-09

C 10 SEP Risk Contributions by Media, Pathway and COC

[redacted]								
Cadmium	5 09E-08	9%	a		a			
Chromium	2 16E-07	36.3%	a		a			
Total by Pathway & Media	2 67E-07	44 9%	a	100%	a	100%	2 67E-07	44.9%
Liner Material on Surface								
Chromium	3.26E-07	NA	a	a	a	NA		
Total by Pathway & Media	3.26E-07	54 9%	NA	NA	NA	NA	3.26E-07	54 9%
Subsurface								
Cadmium	1 40E-09	0.24%	a		a			
Total by Pathway & Media	1 40E-09	0.24%	a		a		1 40E-09	0.24%
Total by Pathway	5 94E-07	100 0%	NA	NA	NA	NA	5.94E-07	100%
[redacted]								
Americium-241	3 60E-07	56.5%	1 07E-06	53 0%	1.48E-06	78 6%		
Plutonium-239/240	2 08E-07	32 7%	6.87E-07	· 34 1%	5 18E-09	0 3%		
Uranium-234	2.83E-08	4 4%	1 15E-07	5 7%	2.59E-09	0 1%		
Uranium-235	1 11E-09	0.2%	4.89E-09	0.2%	2.35E-07	12.5%		
Uranium-238	1.34E-08	2 1%	6 05E-08	3.0%	2.96E-10	0.02%		
Total by Pathway & Media	6 11E-07	95.9%	1.94E-06	96 0%	1 72E-06	91.5%	4.3E-06	94 1%
Liner Material on Surface								
Americium-241	2 16E-08	3 4%	6 41E-08	3.2%	8 88E-08	4 7%		
Uranium-235	2 59E 10	0 0%	1 14E-09	0 1%	5 49E-08	2 9%		
Uranium-238	2.38E-09		1.07E-08		5.25E-11			
Total by Pathway & Media	2 42E-08	3.8%	7.60E-08	3.8%	1 44E-07	7.6%	2E-07	5 4%
Subsurface								
Americium-241	7 94E-10	0 12%	2.36E-09	0 1%	3.26E-09	0.17%		
Plutonium-239/240	1 65E-09	0.26%	5 45E-09	0 3%	4 11E-11	0 0022%		
Uranium-234	1 71E-09	0.27%	6.97E-09	0.3%	1.57E-10	0.008%		
Uranium-235	6.38E 11	0 010%	2 82E-10	0 01%	1.35E-08	0 7%		
Uranium-238	8.23E-10	0 129%	3 72E-09	0 18%	1.82E-11	0 001%		
Total by Pathway & Media	5 05E-09	0 79%	1.88E-08	0.9%	1 70E-08	0 9%	4.09E-08	0.9%
Total by Pathway	6 37E-07	14 0%	2 02E-06	44 4%	1 89E-06	41.5%	5E-06	100%

C 11 SEP Rsk and Hazard Index Summary

[illegible]				
[illegible]				
[illegible]	[illegible]			[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
Surface Soil	2 7E-07	a	a	2 7E-07
Liner	3 3E-07	a	a	3 3E-07
Subsurface Soil	1 4E-09	a	a	1 4E-09
Total Nonradiological Risk				6E-07
	[illegible]			
	Inhalation	Ingestion	External	
Surface Soil	6 1E-07	1 9E-06	1 7E-06	4 3E-06
Liner on Surface	2 4E-08	7 6E-08	1 4E-07	2 4E-07
Subsurface Soil	5 0E-09	1 6E-08	1 8E-08	3 9E-08
Total Radiological Risk				5E-06

[illegible]				
WLRW Hazard Index by Medium and Exposure Pathway				Media
	Inhalation	Ingestion	Dermal	HI
Surface	0 001	0 03	0 006	0 04
Liner	0 001	0 01	0 002	0 01
Subsurface Soil	0 00001	0 001	0 0001	0 001
Total Hazard Index				0 05

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	CDPHE COMMENTS, DATED JANUARY 13, 2003 DRAFT FINAL SEP PAM	RESPONSE
1	**Section 2.1.2 – Power Calculations** First of all, I should state that even after reading this section multiple times, I still do not fully understand what was done and what is being presented in this section I found this section to be quite confusing and would suggest that it be rewritten for transparency as to the methods and findings Although I am not a statistician, I have a hard time imagining any power test that would define one sample as being sufficient to adequately characterize a data set As presented in this report, it appears in Tables 2 2 a, b, & c, that datasets characterized by lognormal distributions require only one or two samples for each analyte I am also unclear as to why there are two MARSSIM columns and two Lognormal columns presented in each table. I think this section requires additional detail as to what was done and what is being presented Additionally, this section appears to rely on results from distributional tests that have not yet been presented and assesses a subset of selected COCs that are discussed/identified later in the document I was unable to determine the rationale for the selection of these COCs in the power calculations (i e., why some chemicals and not others?) The ones selected are not all final COCs	Analytes selected for power calculations were identified as PCOCs in Section 2 3 3, Tables 2 4 through 2 7 Power calculation results were presented in the Data Quality Assessment section to discuss data adequacy and a reference to the PRG Screen results in Section 2 3 3 was added to the report

	In discussing these comments with EPA, a suggestion was made to combine the surface soil and liner data into one dataset for use in the risk assessment By combining the data (no longer treating these two areas separately), there may be sufficient sampling data available to bypass these power calculations altogether and eliminate this entire section from the text	The statistical analysis shows that sufficient samples of both surface soils and liner material were collected Combining the two media will dilute the risk present in surface soil, combine distinct types of media, complicate distributional testing, and provide less information to risk managers on potential sources of risk and necessary remediation Liner and surface soil were therefore not combined, as agreed to with the regulatory agencies in the 1/23/03 meeting
2	**Table 2.2c – Page 13** This table has a footnote of "nc" This footnote is not used anywhere in the table and should be removed	Table 2 2c has been deleted and the conclusions were discussed in the text
3	**Section 2.3.1 – Essential Nutrients** The word "Iris" should be capitalized to read "IRIS" Additionally, this section is missing a conclusion statement that indicates which of the chemicals shown in Table 2 3 are eliminated as COCs based on this nutrient screen A couple of modifications are required in order to make Table 2 3 complete Several of the abbreviations in Table 2 3 need to be defined in the footnotes (i e , RDA/RDI/AI, UL2, ND) The RDA values shown in the table should be referenced as to their source Lastly, since daily intakes (mg/day) are shown in the table (based on an assumed soil ingestion rate of 200 mg/day), the corresponding site concentrations should be provided The maximum is	The word "Iris" was changed to "IRIS" A concluding statement was added to the effect that all nutrients shown in Table 2 3 were eliminated from further consideration based on calculated maximum intakes well below the recommended daily allowances (RDAs), recommended daily intakes (RDIs) adequate intakes (AIs), or upper limit daily nutrient intakes (ULs) and well within background ranges If toxicity values were available for essential nutrients, then they were carried further in the COC screening process i e , iron, manganese All abbreviations, except ND, are defined in the text directly above the table ND was changed to NA=Not available and defined in a footnote

	currently shown, so this would require adding a column for average site soil concentrations Alternatively, since the maximum calculated intakes are below the RDA values, the comparison of mean intake could be eliminated altogether	The source of the RDA value was referenced in Table 2 3 The comparison of mean intake on Table 2 3 was deleted
4	**Figure 2.6 – Page 20** The figure should be updated to show all relevant PRG levels For example, indicate that risk = 1E-06 and HQ = 0 1 are used for comparison with the maximum site concentration Likewise, please adjust the hotspot evaluation to reflect use of a risk = 1E-05 and HQ = 1.0. Additionally, please label the hotspot screen accordingly in the figure, so that readers realize the hotspot nature of the step	Figure 2 6 was updated to show relevant screening target risks The hot spot evaluation was adjusted for risk of 1E-05 and HQ=1 0 on Figure 2 6 The hot spot screen was labeled on Figure 2 6
5	**Section 2.3.5 – Data Distribution Testing** Overall, I agree with EPA's concern over the selection of appropriate tests to determine data distributions If the sample size is less than 50, the EPA QA/G-9 guidance recommends the use the Shapiro-Wilk W test, wherever practicable If the sample size is greater than 50, the guidance recommends using either the Filliben's statistic or the studentized range test However, if critical values for these tests (for the specific sample size) are not available, then this guidance recommends implementing either Geary's test or the Lilliefors Kolmogorov-Smirnoff test Just because a software package contains multiple methods for determining a distribution, this does not imply that all methods are equally valid for a particular data set I would	Distributional testing was modified as agreed to use the Shapiro-Wilk test n<50, Fillibens n=50-100, and Geary's n>100 A weight of evidence approach was initially used to derive distributions based on results from five tests

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	suggest adhering to the guidance and using the most applicable test for each data set being evaluated As currently written, there are many potential problems with the approach provided in the December 2002 SEP reports The EPA QA/G-9 report identifies limitations to several of these methods that are included For example, Geary's test is recommended for data sets with greater than 50 samples The SEP report uses this test for sample sizes of 15 in the liner material. Additionally, G-9 indicates that "this test does not perform as well as the Shapiro-Wilk test or the studentized range test" However, it appears that the SEP report has given equal weight to this test, despite these limitations Likewise, the Coefficient of Variation test (CV) can be used to determine that a curve is not normal (i e , CV > 1). However, as clearly stated in G-9, this method should not be used to conclude that data can be modeled with a normal curve if the CV is less than 1 This method should be applied only to quickly discard an assumption of normality, and not to conclude normality The SEP report attempts to use this method contrary to its intended use, by assuming normality based on test statistics. The only result that is applicable in the report tables under the heading "CV" is the "No" value (discarding normality) The "Yes" values should be removed and not considered in the evaluation process I also agree with EPA's concern regarding the decision that the data are to be treated as non-parametric when the results	In accordance with the DOE/regulatory agency agreement at the

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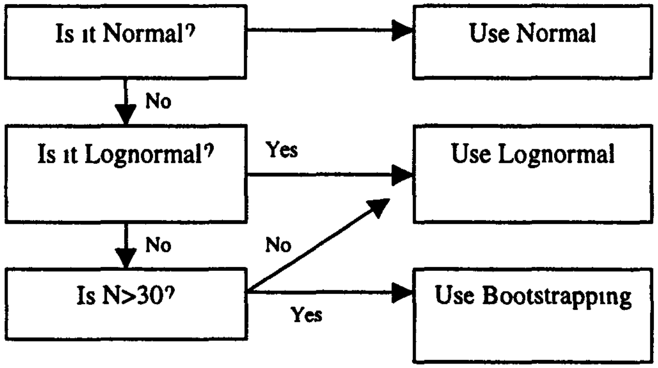
indicate that both the normal and lognormal distribution apply My general thought for application at this site, is that if the data pass the test for normality, there is no reason to test for log-normality I have provided a brief flowchart of decision logic



Based on further discussions with EPA regarding these comments, we feel that there are two solutions to proceeding with the distributional testing. The first is to simply use the Shapiro-Wilk test for data sets less than 50 and the Shapiro-Francias test for sets >50 to determine normality/lognormality according to the flowchart provided above For datasets containing negative values, first test for normality and if the analyte fails this test, move directly to Bootstrapping methodology The second resolution would be to input the data in the Pro-UCL software and use the software's recommendation for applicable distribution test

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January 23, 2003 meeting, data were assumed to be normally distributed even of testing indicated that the data were also lognormally distributed

The flow chart was followed, however lognormality was not assumed for n<30 due to technical difficulties discussed by EPA (2002) and with the regulatory agencies

As agreed, no distributional assumption was made for all liner PCOCs with n=15 and maximum detected concentrations were carried into the risk assessment and used to conservatively estimate risk

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</table>

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6	**Table 2.9 – Page 25** The sample counts shown in the left hand column need to be updated to reflect the number of samples collected in background surface soil samples, rather than the number of samples collected in the liner, as is currently shown	Table 2 9 was corrected to list the number of samples collected in background surface soil
7	**Page 25 – Surface Soils Data Evaluation** The text indicates that surface soil data were evaluated for each PCOC with a maximum above the WRW PRG Results from distributional testing are shown for 10 analytes in surface soil, however, 12 chemicals were found to fail the PRG screen Please include distributional testing for Benzo(a)pyrene and Dibenzo(a,h)anthracene	These organic analytes were added to Table 2 8
8	**Page 26 – Subsurface Soils Data Evaluation** The text indicates that distributions were evaluated for all PCOCs retained in the PRG screen This section leaves out the result for distributional testing of benzo(a)pyrene, a chemical which was retained in the PRG screen	These organic analytes were discussed in Section 2 3 5 in the text for surface soil and were not PCOCs in subsurface soil
9	**Table 2.13 – Page 27.** The abbreviation "na" is given for Am-241 under the S/K test for normality Please footnote the table with a relevant description	The Table 2 13 footnote for abbreviation "na" was corrected to state that the Fillibens test was not applicable with a sample size < 50 and a Shapiro-Wilk test was performed

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10	**Page 31 – First full sentence** This sentence refers the reader to a non-existent Section 2 8 for further discussion.	 The text in Section 2 3 6 was changed and the referenced section deleted
11	**Page 31 – Application of Professional Judgment** For benzo(a)pyrene the 95UCL, calculated using a Bootstrap methodology, is compared to the WRW PRG value. The document does not show results from the distributional testing for this analyte that supports use of the nonparametric Bootstrapping statistics The underlying distribution (normal, lognormal, nonparametic) for this data set should be shown prior to calculating a 95UCL value	 The distributional tests were added in the appropriate section of the report and final distributions assigned in Table 2 8 95UCLs were derived for these two analytes and were used in the professional judgement discussion to eliminate these PCOCs
12	**Table 2.15 to 2.17 – Page 33-35** I am confused as to what is being shown in these Tables Based on the paragraph immediately preceding Table 2 15 that states, "Only compounds listed in ALF were assessed for the risk assessment, per agreement All analytes listed in ALF had toxicity factors Tables 2.15 through 2 17 list analytes with no PRGs in ALF" one would assume that these chemicals are in the ALF listings, have toxicity factors, but are merely lacking the calculation of a corresponding PRG value If so, what is the barrier to calculating a PRG? It could be that the wording is confusing and that this is a	 Analytes not on the ALF list or without toxicity values were not evaluated in the SEP risk assessment as agreed to with the regulatory agencies at the January 23, 2003 meeting The text in section was corrected for clarification Tables 2 15 through 2 17 were placed in Appendix A (Tables A 80 through A82) as suggested

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	listing of the non-ALF chemicals that will not be addressed Please explain if these are or are not ALF chemicals If not, it has already been stated that only ALF chemicals are to be evaluated per agreement with the agencies; therefore, I don't see a reason to present these tables in the body of the risk assessment, as it may lead to confusion They may be better placed as an appendix, if deemed necessary I am assuming that these individual records are already presented in one of the appendices that lists comprehensive summary statistics for all analytes by media Additionally, several of these analytes (calcium, magnesium, potassium, silicon, and sodium) have already been addressed in Section 2 3 1 The discussion of whether or not these are ALF-based chemicals is relevant to their inclusion If they are in fact ALF compounds, several of the data gaps could be resolved For example, thallium and ethyl acetate are listed in these tables, but have oral RfDs in IRIS Additionally, HEAST has numerous values that could be used to derive PRGs for the radionuclides I did not check all of the analytes to determine if other toxicity data gaps could be resolved	

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13	**Tables 2.18 to 2.20 – Pages 36 & 37** There is a footnote on these tables that indicates the data were calculated using Bootstrap resampling methodology It is unclear as to what in these tables would have been derived using Bootstrapping, since they present only summaries of count and detection frequency for each COC	The footnote was deleted from Tables in question Also these tables were combined into a single table – Table 2 14
14	**Section 3.1 – Future On-site Land Use** If you wish to bring up the discussion on the presence of Preble's habitat at the site, the risk assessment should explain how this will be addressed, rather than ignoring this land use when identifying exposure pathways and receptors	The discussion in Section 3 1was deleted
15	**Page 30 – Future On-site WRW** The text indicates that the worker will spend 50% of each day outdoors across the Site with <u>an emphasis near the watershed areas</u> Either remove this language or reference how this was determined, as I feel that an exposure location is dependent on the activity being performed For example, someone conducting a prairie dog survey would not be expected to preferentially visit the watershed areas For the purposes of the SEP risk assessment, it is assumed that random exposure may occur across the entire AOC, with no preference towards a specific sub-location	The text in Section 3 1 was deleted

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<table>
<tr><td>16</td><td>Section 3.3 – Exposure Scenarios

The receptors for evaluation in the CRA are still undergoing negotiation Therefore, it is premature to state that risks to off-site receptors "will be addressed in the Site CRA</td><td>The CRA will address the off-site receptor if required</td></tr>
<tr><td>17</td><td>Section 3.4 – Exposure Point Concentrations

In the first paragraph, the text states that problems arise with assuming lognormality when data are not lognormally distributed Please expand this discussion by referencing the types of problems that are known to occur, rather than just making this simple statement</td><td>The text in Section 3 4 was deleted</td></tr>
<tr><td>18</td><td>Page 46 – First Paragraph

Please provide more details on the Bootstrapping methods that were used for the SEP risk assessment There are many different variations of the Bootstrap method that have been developed, and I am unfamiliar with what options are offered in the S-Plus software package According to several sources, the number of Bootstrap samples appropriate for developing reliable confidence limits depends on the statistic of interest and the acceptable error in the interval A minimum of 1,000 replicates is generally recommended and was used for the SEP risk assessment Please address that 1,000 replicates was sufficient to characterize the statistic of interest</td><td>Additional details on the Bootstrapping methods used in the SEP risk assessment were added to the text

An analysis of the effect of increased iterations on estimates of the mean and variance was conducted and added to the Uncertainty Section as Section 5 3 5 This analysis confirmed that 1,000 iterations is sufficient The error associated with Bootstrap iterations is well below analytical errors and other significant sources of uncertainty in the SEP risk assessment</td></tr>
</table>

19	**Table 3.3 – Page 47** It would be much more helpful to have a table that shows the underlying data distribution determined for each chemical, as well as a column summarizing the final EPC value used for the risk calculations In some cases (e g , Americium), the EPC value defaults to the maximum detected concentration This is not always clear to the reader and a summary column would eliminate potential confusion As a side note, I see summary statistics provided for the mineral uranium in this table I do not recall seeing the mineral form brought through the COC selection process Based on the final risk values shown at the end of the document, this could very well end up being eliminated *a priori* as a COC This analyte should follow the same procedures established for the other analytes in this risk assessment	Data distribution types were added to Table 3 3 A footnote was added to the table to indicate that maximum concentrations for all liner COCs was used Those 95UCLs used in the SEP risk assessment were bolded in Table 3 3 The concentration values for the mineral form of uranium were derived from isotopic analytical results The non-carcinogenic assessment for these derived values was also included to assess the possible chemical toxicity of uranium The worksheet with the conversion to mass units is given in Appendix C, Table C 3
20	**Table 5.1 & 5.2 – Pages 56 & 57** Why don't the HI values presented in Table 5 1 (by medium) match the HI values shown in Table 5 2? For example, Table 5 1 shows a dermal HI for surface soil of 0 008, whereas Table 5 2 has a summed dermal HI for surface soil of 0 006	The values in Tables 5 1 and 5 2 were modified as necessary to correct for rounding errors

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21	**Page 61 – First Paragraph** Change "assign" to "assigned" The text states that "distributional testing was also conducted for individual surface soil COCs using the Shapiro-Wilk test on the data and Ln-transformed data " This statement does not accurately reflect what was presented in earlier portions of the text	 The text was changed from "assign" to "assigned" The text was corrected as appropriate
22	**Page 61 – Third Paragraph** This paragraph indicates that "The Bootstrap method was used to calculate UCLs for the SEP Risk Assessment" This example is partially why I found this document to be confusing In fact, the Bootstrap method was only used to calculate UCLs for those analytes that were determined to have non-parametric distributions and sampling sizes greater than 30 (at least that is what I thought happened) If this section is designed to compare UCLs calculated via multiple methods, simply state that Do not confuse the reader by implying that the presented values were used to calculate site risks The table is footnoted that the lognormal statistics (based on who knows which of 5 tests) were not applicable for some of the analytes, since their distributions were not lognormal at the 0 05 level This same evaluation was not performed for the assumption of normality Of the chemicals presented, none were determined to have normal	 This text was changed to clarify that the non-parametric Bootstrap method was only used for those COCs with assigned non-parametric distributions or radionuclides with negative numbers as agreed to and in accordance with EPA guidance Consequently, a U-Test was performed for these analytes and the results are presented in Table 2 13 Table 5 5 on page 61 was deleted Table 2 13 was modified to indicate what test was applied to test against background based on assigned distributions All COCs retained following the background screen based on statistical testing were found to have either non-parametric or lognormal distributions As a result Table 2 13 indicates which UCLs were based on the

	distributions in Table 2 10, therefore, comparing the Bootstrap or geostatistics value to this "normal" UCL95 value and declaring a similarity is inappropriate, since it has already been determined that the assumption of normality for this dataset is inappropriate In fact, since the default is to assume a lognormal assumption, it seems more appropriate to compare the Bootstrap and geostatistical values to the lognormal UCL	Bootstrap analysis or a T-Test performed on the log-transformed data
	EPA COMMENTS, DATED DECEMBER 2002 DRAFT FINAL SEP PAM	
	EPA- EPA TOXICOLOGICAL REVIEW: General Comments	
1	Oddly enough, this revision appears to be further away from completion than the previous draft There are still a number of errors in the report which need to be corrected However, my major concern is with the process used to determine distribution shapes and exposure point concentration terms for the contaminants of concern (COCs) Instead of following the simpler, straight forward approach recommended by EPA and CDPHE in previous meetings and memorandums, the document uses an overly complex, and in my opinion, unnecessary approach for testing distribution shapes, and presents the results in an incomplete and confusing manner In addition, the credibility of the document is not enhanced by numerous sections criticizing the methodologies recommended by EPA and CDPHE My specific comments are as follows	The distributional testing was modified to conform to the agreed upon methodology Shapiro-Wilk test n<50, Fillibens n=50-100, and Geary's n>100

	SPECIFIC COMMENTS:	
1	**Page 24, Section 2.3.5 Data Distribution Testing** Instead of using one statistical test for normality, the authors used five If DOE chooses to spend the time and resources pursuing this level of detail, I have no problem However, each test was intended to be used for different types of data sets with different detection limits, distributions, sample size, etc This is not explained in the document As written, the document gives equal weight to all of the tests The second bullet on page 24 states that two or more "no" results for the tests indicates that the data did not conform to the distribution being tested This is not a very useful or technically accurate guideline if the two tests with the "no" results are inappropriate for the specific data sets being tested This section needs to be revised I've outlined two approaches below which would result in a document satisfactory to both EPA and CDPHE Simplify the approach for testing distribution shapes as recommended by EPA and CDPHE in previous meetings Specifically, use *one* test for normality for samples sizes less than 50, such as the Shapiro-Wilks, and use *one* test for samples sizes greater than 50, such as the Shapiro-Francia test Follow the diagram provided by CDPHE in interpreting the results of the test Specifically, if the results indicate the data set is normal, then use the normal distribution If the results are not normal, then test for lognormality If the results indicate lognormality, then assume lognormality If the results are neither normal, nor	The distributional testing was modified to conform to the agreed upon methodology Shapiro-Wilk test n<50, Fillibens n=50-100, and Geary's n>100 No decision logic was therefore required The testing for distributions was modified per agreement as follows ◆ If data set is normal, then use the normal distribution ◆ If the results are lognormal, then assume lognormality ◆ If the results are neither normal, nor lognormal, then assume they are non-parametric ◆ If sample size is less than n=30 then no distribution will be

	lognormal, then assume they are non-parametric Sample sizes less than 30 are to be treated as lognormally distributed	assumed and maximum detected concentrations will be used to estimate risk
	Use a more complex approach utilizing multiple tests for testing distribution shapes The major problem with the current draft is that multiple tests are used, however, no effort was made to evaluate the appropriateness of the tests to the site-specific data sets We recommend that DOE use the new EPA ProUCL (Version 2 1) software The software will run multiple tests evaluating distribution shapes, recommend the appropriate distribution for each specific data set and calculate the exposure point concentration based on the recommended distribution	The testing was modified as agreed
	The third bullet on page 24 states that the data are to be treated as non-parametric when the results indicate that both the normal and lognormal distribution apply We don't agree with this decision rule If the data are shown to be normal, then assume a normal distribution Do not proceed with any further testing Data sets for which either the normal or lognormal distributions fit are exhibiting low variability The choice of the normal distribution is not only reasonable, but it is also to the advantage of the regulated party	Comment noted
	The 4th bullet on page 24 states that radiological data with zero and negative concentrations are considered normal or non-parametric I agree with this approach	

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2	**Page 25, Surface Soil Data Evaluation** The 2nd paragraph states that none of the surface soil COCS were classified as normal or lognormal Yet, Table 2 10 shows arsenic as being normally distributed This sentence needs to be revised	The text was corrected following a re-testing of analyte distributions No normal distributions of COCs were found in surface soil
3	**Page 44, 4th bullet** The fourth bullet references a 1991 EPA guidance which is outdated and has been superceded The paragraph should be revised to explain that the equations and parameters for the radionuclide external exposure pathway are taken from the October 2000 *Soil Screening Guidance for Radionuclides User's Guide* Also, note that the mass loading factor used in Tables 3 1 ands 3 2 has changed back to the 50th percentile value In the last draft final we reviewed, the mass loading value was consistent with the RSAL Task 3 report. Although I think this is a more realistic value, you and Carl should be aware that it will be different and be prepared to respond to the public	The reference was changed as suggested The text was also augmented as suggested The mass loading using the 50th percentile from the RSAL report was used
4	**Page 45, Section 3.4 Exposure Point Concentrations** The first sentence under this section appears to have escaped the revisionists pen from earlier rounds The sentence should state that the exposure point concentration is the 95 UCL on the arithmetic mean Period The clause "assuming normality" is an error and should be deleted	The text was changed as suggested

	The 7th line down in the first paragraph is written awkwardly, if not erroneously It states that a *geometric mean* and 95UCL are calculated when data distributions are demonstrated to be lognormal This sentence should be revised to state that the *arithmetic mean* and 95 UCL of the transformed data are calculated when a distribution is lognormal Any calculations of exposure point concentrations performed on lognormal data sets should be re-checked because the use of one versus the other results in marked differences	The text was changed as suggested
5	**Page 46, 1st full paragraph** *Note EPA and CDPHE are requesting that the liner data be combined with the surface soil data within the SEP In that event, this comment is no longer specific to the liner data, but this should not preclude a revision to Table 3 3 to clarify the text* The 9th line down in the 1st full paragraph states that lognormality was assumed for all final COCs in liner material based on direction from EPA, CDPHE to assume lognormality for all data sets with less than 30 samples This is correct However, this section is written in a confusing manner and it is not easy to see what was actually used as a concentration point exposure term The easiest way to resolve the confusion is to revise Table 3 3 in Section 3 4 adding columns to clearly show the distribution shape assumption *used in the calculation* for each analyte as well as the actual exposure point concentration term chosen A footnote should be added to the table explaining the	 The statistical analysis shows that sufficient samples of both surface soils and liner material were collected Combining the two media will dilute the risk present in surface soil, combine distinct types of media, complicate distributional testing, and provide less information to risk managers on potential sources of risk and necessary remediation Liner and surface soil were therefore not combined, as agreed to with the regulatory agencies in the 1/23/03 meeting Table 3 3 was revised to show distributions used in subsequent calculations for each analyte No distributions were assumed for all liner COCs as agreed, due to small sample size

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	policy decision The last paragraph on page 46 contains a typo in the 5th line "UCLf or" should be "UCL for"	 This paragraph was rewritten
6	**Page 47** The 1st paragraph explains that the maximum value of 8 1 was used as the EPC for americium instead of the 95% UCL This should be shown on Table 3 3 in an additional column The last sentence on page 47 states that all COCs in surface soil had non-parametric distributions Table 2-10 on page 25 shows differently The sentence should be revised	 Table 3 3 was footnoted to explain that the maximum values were used for all liner COCs The text was changed
7	**Page 49, Table 3.4** The risk equation for external radiation risk is missing the gamma shielding factor	 The risk equation for external radiation risk was corrected to include the gamma shielding factor

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8	**Page 53, Table 4.1, Toxicity Factors** The 3rd column in Table 4 1, labeled "DAF fraction" appears to confuse a dermal absorption fraction, which is a variable in the exposure equation, with a gastrointestinal absorption efficiencies which are used to adust the oral toxicity values Exhibit 4-1 in EPA's 2002 Dermal Guidance provides absorption efficiencies of 2 5% for both cadmium and chromium These values should be used to adjust the toxicity values If an absorption efficiency is 50% or greater, the toxicity value should not be adjusted	Text was modified to explain that the gut absorption of 2 5% for chromium and cadmium was used to adjust the oral RfD
9	**Page 61, 2rd paragraph** The second paragraph implies that the methods recommended by EPA and CDPHE to test for distribution and calculate the exposure point concentration term are inappropriate This does not add to the credibility of the report and should be deleted from text	This paragraph was deleted The reader is referred to Attachment 1 concerning Data Adequacy for a discussion of geostatistical analysis and effect of various distributional assumptions on 95UCLs
	EPA STATISTICAL REVIEW:	
1	**Section 1.0, Page 1, last sentence.** Ecological risk is not addressed in this human health risk assessment (HHRA), but will be addressed in the future The proposed remedial action is to bulldoze the earthen berms and cover the asphalt liners of the Solar Evaporation Ponds (SEP) as soon as regulatory is obtained. Regulatory approval would follow a finding by the Colorado	Ecological risk will be addressed in the CRA to assess potential impacts to populations of ecological receptors over larger exposure units

	Department of Public Health and the Environment (CDPHE) and U S Environmental Protection Agency (EPA) that human health risks are not significant and no excavation of contaminated soil or liner material is required The intended remedial action does not address the possible outcomes of the ecological risk assessment, including the possibility of significant risk to an ecological receptor These issues should be addressed.	
2	**Section 1.1, Page 2.** This section states, "Contaminated liquids apparently infiltrated into subsurface soil " This statement is unclear The word "apparently" should be deleted	The word "apparently" was deleted
3	**Section 2.1.1, Page 8.** Only 15 asphalt liner samples were collected for metals and radionuclides Yet in the summary on page 10, data quantity is stated to be acceptable for HHRA purposes It is not clear how 15 samples can meet the data quality objective (DQO) Liner data should be combined with surface soil data	The statistical analysis shows that sufficient samples of both surface soils and liner material were collected Combining the two media will dilute the risk present in surface soil, combine distinct types of media, complicate distributional testing, and provide less information to risk managers on potential sources of risk and necessary remediation Liner and surface soil were therefore not combined, as agreed to with the regulatory agencies in the 1/23/03 meeting Data adequacy was demonstrated to be adequate using non-parametric power calculations and a PARCC analysis

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4	**Section 2.1.2, Page 10.** A previous submittal dated September 11, 2002, included responses to CDPHE and EPA Comments on the Solar Evaporation Ponds Project In that document, 66 samples per the Gilbert equation power calculation (13 23) was determined as the minimum sample size necessary to characterize surface soil radionuclides This Gilbert equation uses the median rather than the 95 upper confidence level (UCL) and therefore is not conservative The new method, that calculates relative errors as the difference between the PRG or action level and the mean or 95UCL, results in only one sample being required The MARSSIM method results in 13 samples being required An order of magnitude difference between these two results is cause for skepticism regarding this approach It appears that the new method used in the third HHRA is an attempt to justify the collection of only 15 liner samples The present strategy attempts to discount the need for calculating the 95UCL to any precision by demonstrating the large difference between its value and the preliminary remediation goal (PRG) associated with a risk of one in hundred thousand (1E-05) However, the strategy fails, because not enough samples have been analyzed to reliably estimate the 95UCL As an example, if the Gilbert equation requires 66 samples to estimate the median of a lognormal distribution with a relative error of 10 percent and confidence of 95 percent,	The previous analysis in Attachment 1 is based on SOR data for surface soil radionuclides assuming lognormality for the data The relative error was arbitrarily set at 10% These conditions led to an estimate of 66 samples The recent analysis in the SEP risk assessment assesses required numbers of samples for each analyte as requested by the agencies, relative errors based on the actual differences between the mean or 95UCLs, and the soil action limits at 1E-05 or HQ=1 0 risk levels The larger, but more correct relative errors reduced the predicted number of samples required A power calculation substantiates that sufficient liner samples were collected to support risk assessment The text concerning power calculations was revised to clarify how the calculations were performed specific to each COC and explain the results The result of 1 using a lognormal calculation indicates that enough samples have already been collected This result does not mean that only a single sample would be required The default result of 13 for the MARSSIM analysis also indicates that sufficient samples have been collected Based on the samples collected and the estimated values for the mean and variance relative to the mean, the action levels will not be exceeded at the 95 percent level of significance Therefore the samples collected are adequate All power calculations were conducted following standard procedures found in NUREG-1575, EPA documents, and by

	the lognormal variance can be back calculated as 0 156 Substituting this variance and assuming the number of samples required is 1, the Gilbert equation can be solved for d, the relative percent error (same as beta * 100 percent) allowed The answer is 116 9 or ~117% Because power = 1- beta = 1 - 1 17 = - 0 17, one sample has no power to determine the 95UCL All power calculations should be recalculated in a manner consistent with standard statistical practice per the previous submittal but on individual PCOCs Also, an alternative approach should be considered If the Liner data are combined with surface soil data typically resulting in ~85 samples per PCOC, the DQO will be considered achieved and Section 2 1.2 Power Calculations should be removed from the risk assessment	Gilbert (1987) Liner materials and surface soil were not combined as previously discussed in response to EPA comment 5
5	**Figure 2.6, Page 20.** It is unclear why potential contaminants of concern (PCOCs) at concentrations corresponding to less than 3E-05 were deleted from further analysis if the target risk level is 1E-05 The rationale for eliminating these PCOCs from the analysis should be provided	 The text was augmented to explain how and why a hot spot screen was conducted
6	**Section 2.3.5,Pages 23-27.** Using five tests of normality in a weight-of-evidence approach is acceptable However, requiring 4 of 5 tests to be "yes" is too stringent, three of five tests should be	 Distributional testing was modified as discussed in EPA Specific Comment 2 and agreed upon with the agencies

	acceptable Some of the normality tests chosen are questionable in terms of power and sample size As such, the tests should not be given equal weight as they have been The third bullet on page 24 is incorrect as stated, and the final distribution in Tables 2 8, 2 9 and 2 11 are also incorrect in many instances These items should be corrected An alternative simpler approach is recommended One test, the Shapiro-Wilk W test is sufficiently stringent to be acceptable by itself. Many standard statistical packages give the probability (p) of fit of the Shapiro-Wilk W test Also, the Shapiro-Francia test is an extension of the Shapiro-Wilk test good for sample sizes up to 2000 The Lilliefors test is also acceptable for sample sizes > 50 ProUCL v 2 1, freeware, can perform the Shapiro-Wilk W and Lilliefors tests	
7	**Section 2.3.7, Pages 33 to 35 and Tables 2.15 to 2.17.** It is stated that only compounds listed in ALF were assessed for the HHRA The text does not include which compounds were dropped or why, if all parameters are available to calculate risk, the compounds were dropped This information should be included	This text was clarified to state that those analytes not on ALF were not evaluated Tables of all dropped analytes and summary statistics were included and have been moved to Appendix C

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8	**Section 3.4, Page 46, First Paragraph.** Most Bootstrap tests mention 1,000 or 2,000 replications as sufficient Five thousand, 10,000 or more would be better, but results would probably be only slightly greater An adequate number of replications may be found with a decision rule such that doubling the number of replications results in a numerical change of say only 1 percent or whatever is deemed acceptable There is no hard and fast rule on the percentage chosen A check that 1,000 replications are sufficient should be conducted by performing more until the final result agrees to within 1% of the previous result	An analysis was conducted to evaluate the effect of increasing the number of iterations on the resulting mean and variance using the Bootstrap method This evaluation was added to the Uncertainty section as Section 5 3 5 The conclusion was that the impact is negligible and below other sources of error impacting risk
9	**Section 3.4, Section 3.4, Page 47, first sentence and Table 3.3.** The text states 8 1 pCi/g for Americium-241 was used to calculate risk However, the maximum value in Table 3 3 is given as 8 19 pCi/g which rounds to 8 2 pCi/g Only the final answer in all risk equations should be rounded in accordance with standard practice	The rounding error was corrected
10	**Section 5.4, Pages 58-59, Section 5.4.3, Page 65 and Section 6.0, Page 66, Last Bullet.** This section and the summary stress the uncertainties associated with conservative assumptions in the HHRA and states that actual risks may be lower However, chemicals	The uncertainty section was modified to include the possible effect of not evaluating non-ALF and analytes without toxicity values However, due to essential nutrients and other analytes with no known historical use on the site, it is expected that

	that are not on the Action Levels and Standards Framework for Surface Water, Ground Water, and Soil (ALF) list are not evaluated. In addition, chemicals without toxicity values are not evaluated The HHRA states that this adds a degree of uncertainty to the risk assessment, failing to acknowledge that this may result in actual risks being higher A statement should be added that acknowledges risks may be higher as a result of not evaluating chemicals	omission of these analytes could increase risk but will have a minimal impact
11	**Section 5.4, Page 61, second paragraph and Table 5.5.** This paragraph states that "good spatial correlation" occurred among the COC data that, in turn, dictates use of geostatistics This conclusion negates everything presented previously in this HHRA where classical statistics were employed Considering that the pattern of historical contamination was probably randomly located spills as opposed to continuously distributed spills, both classical statistics and spatial statistics have some merit, but neither is perfect The three paragraphs beginning with "In addition, a Geostatistical Spatial Analysis . " leading to the subsection Mass Loading and Air Exposure Concentrations should be removed from the risk assessment A discussion of the differences in UCLs obtained by the different statistical methods could be included in the Uncertainties section of the risk assessment In any case, since none of the COCs in Table 5 5 were normally distributed as shown in Table 2 10,	This discussion was deleted The discussion and Table 5 5 were deleted Re-testing results indicated that Fe had a normal distribution The calculation of normal 95UCLs was conducted to compare the effect of distributional assumptions on the 95UCL However, this discussion was removed from the risk assessment and only appears in Attachment I

	the normal column in the table is irrelevant and should be removed	
	Additional Comments on Appendix A	
	Time constraints necessitated that review of Appendix A be confined to one important COC, Americium-241 There are unresolved issues with the database being used for the risk assessment as enumerated below Numerous apparent errors were found suggesting a disconnect between Appendix A and the risk assessment text and tables	See following comment responses
1	**Appendix A, Table A.3 - Solar Evaporation Ponds AOC Analytical Results for Surface Soils Radionuclides, Page 1 and Table A.13a** There are 69 Americium-241 surface soil samples in the Appendix A database Gannett Fleming (GF) also prepared a database for the Rocky Flats SEP The GF database has 54 Americium-241 surface soil samples The largest Americium-241 concentration reported in Appendix A is 130 pCi/g The largest Americium-241 concentration reported in the GF database is 220 pCi/g These data discrepancies should be explained before any confidence can be placed in the Appendix A database Assuming the database in Appendix A is correct, Americium-241 is lognormally distributed according to the Shapiro-Francia test (p = 0 07) The arithmetic mean is 8 69 pCi/g as reported in Table A 13a. But Table 3 3 in the RA	Gannett Fleming has a different data set than the one used for the SEP risk assessment and submitted to the agencies DOE is not familiar with the data set GF developed or how this data set was screened The result of 220 pCi/g was a rejected data record and could not be used in the risk assessment The SEP risk assessment is based on the screened, finalized, and submitted data set that K-H developed The differences in mean values from Table 3 3 and the Appendix A are due to Bootstrap values in the Table and calculated means in the Appendix A footnote was added to Table 3 3 to explain this difference Distributions were added to Table 3 3

	reports 9 11 pCi/g as the mean All numerical inconsistencies between Appendix A and the risk assessment text should be resolved A column should be added to Table 3 3 citing the source of the 95UCL concentration (normal, lognormal, Bootstrap)	All discrepancies between Appendix A and the risk assessment text were resolved
2	**Appendix A, Table A.5 Solar Evaporation Ponds AOC - Analytical Results for Liner - Radionuclides, page I and Appendix A. Table A.13b Solar Evaporation Ponds AOC - Summary Statistics for Detected Analytes in Liner** Six of 15 Americium-241 Liner samples show a lab result qualifier as "<" which would seem to indicate the samples are non-detects The magnitude of these results also suggests these samples are non-detects with two levels of censoring (0 003 and 0 005 pCi/g) However, Table A 13b indicates 100% detections for these 15 Americium-241 Liner samples Also, Table 2 19 page 37 of the RA indicates these data are non-detects by reporting a detection frequency of 60% These discrepancies should be corrected The same discrepancies occur for Liner COCs other than Americium-241 These should also be corrected	The six liner results are "less than" values However the results have no laboratory or validation qualifiers or an RC Sigma result to evaluate in the SWD database Professional judgment was therefore used to treat these results as non-detects The Appendix A frequency of detection was therefore changed to 60% All other discrepancies for liner data were corrected

3	**Appendix A, Table A.24-A.79** No Liner results were found in these background comparison tables The use of surface soil background as "surrogate" Liner background as stated on page 28 of the risk assessment is inappropriate and unacceptable However, since the Liner samples are to be combined with the surface soil samples to meet the DQO, the use of background surface soil for the background comparison will then be acceptable	Liner data were compared to surface soil limits because no other limits were available This was stated in the risk assessment text Liner and surface soil were not combined as previously discussed in CDPHE comment 1
4	**Appendix A** No background data were found Reference is made to documents containing background data in the risk assessment All data used in the risk assessment should appear somewhere in the risk assessment or appendices	Background data were added to Appendix A as Tables 83 through 88
	A Table of Contents should be added to Appendix A	A table of contents was added to Appendix A

SEP Risk Assessment
Meeting Notes
1/23/03

Attendees
CDPHE Steve Gunderson, Tracy Hammond, Carl Spreng
EPA Robin Blackburn, Susan Griffin, Tim Rehder
U S F&W Mark Sattelberg
DOE Norma Castaneda, Russ McCallister
Kaiser-Hill Marla Broussard, Lane Butler, Lee Norland
K-H Team Jere Millard, Rick Roberts, Susan Serreze

The purpose of this meeting was to discuss CDPHE and EPA comments on the Draft Final SEP RA (December 2002)

S Gunderson stated that agency concerns centered on statistics

L Butler summarized 6 key issues related to CDPHE and EPA comments

The first issue was document clarity DOE will rewrite Section 2 and resolve data discrepancies

Power calculations and data adequacy were discussed

J Millard stated that the power calculation is not intended to justify taking one sample, but to explain data adequacy

C Spreng stated that the bottom line is that the current sampling is adequate

L Butler asked for agency concurrence that this issue was resolved

T Hammond stated yes, and that she had trouble following the document

Distributional testing was discussed

T Hammond stated that some of the distributional tests were not appropriate

J Millard stated that 5 tests were used and that the software does not allow use of all tests

T Hammond stated that all 5 tests were given equal weight, which is not appropriate

J Millard stated that he does not want to rely on only one test but will do so if required by the regulatory agencies

T Hammond stated that the preference for use of either PRO-TL software or 1 test The PRO-TL software does not give all tests equal weight

J Millard stated that DOE will use one or the other for the RA

L Butler clarified that DOE will use the Shapiro-Wilks test for COCs with less than 50 results, and the Shapiro-Francias for COCs with more than 50 results

S Griffin suggested using 1 test for 1 comparison

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L Butler clarified that DOE will use the Shapiro-Wilks test for COCs with less than 50 results, Fillibans test for COCs with more than 50 results, and Geary's test for COCs with more than 100 results

S Gunderson stated that all 3 tests will be used depending on the analyte

J Millard stated that DOE will follow the EPA flow chart for normal distributions He also stated that this was not used in the SEP RA because he did not want to throw away data before the distributional testing For lognormality, he will follow the EPA guidance, which leads to the Bootstrapping method when there is less than 30 samples Based on 2002 EPA Guidance and the Singh paper, lognormal statistics resulted in the PROTEL statistics A large sample population would be treated as lognormal, for a small sample size, the h statistic would not be used, but one would go directly to Bootstrapping Nonparametric methods perform better than lognormal methods Using lognormality is not a valid technique because it results in numbers that are misleading

For example Americium has a maximum value of 8 1 pCi/g, but the lognormal value is greater than 10,000 Using nonparametric methods the result is 8 It would be difficult to explain this very large number to the public

S Griffin stated that the Bootstrapping method is intended for well-characterized sites If there are less than 30 samples, the site is not well characterized and more prudence is needed If the lognormal method results in a value of greater than 10,000 the procedure is to default to the maximum value The tables in the text need to show the maximum value and the 10,000 should be shown in an appendix

L Butler clarified that there is no difference in the risk result

J Millard stated that the assumption of lognormality is the issue

S Griffin stated that using lognormality you can default to the maximum value and if you use nonparametric methods use the value generated

J Millard stated that the assumption of lognormality is not defensible, and that EPA guidance states using the Bootstrapping method. J Millard wants to follow this EPA guidance

S Griffin stated that the text of the guidance states if you are not comfortable with the adequacy of the characterization then you should use lognormal methods

J Millard stated that this was not in the guidance

S Griffin stated that this is in the guidance

R Roberts asked if the MARSSIM 13 samples are adequate characterization for Bootstrapping

S Griffin stated that the power calculations did not convince her that the liner is well characterized, so she wants the liner data combined with the surface soil data This will make the whole issue go away

T Hammond stated that 66 samples were needed

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J Millard stated that 66 samples were needed for the SORs not analyte by analyte The analyte by analyte calculations were conducted as specified by the regulatory agencies Standard G-4 methods were used and there is nothing wrong with the calculations

L Butler clarified that recalculation will not change the risk and with a limited budget there is no reason to recalculate

J Millard stated that combining the liner with surface soil will dilute the risk, that the liners received primary waste and were remediated while the soil received secondary waste, and combining the liner with surface soil is not technically correct

S Griffin stated whether the line and surface soil are separate or combined doesn't matter, but if the sample size is less than 30, a lognormal distribution must be used

T Rehder asked if we could agree to disagree and use the lognormal distribution at the request of the agencies

L Butler stated that this would result in the 10,000 pCi/g Americium appearing in the report

J Millard stated that a disclaimer could be written

C Spreng stated that the existing document already has this and the alternative calculation could be put in an appendix

L Butler clarified that the distributional testing for samples sets less than 30 samples will be added to the data adequacy attachment

S Griffin stated that this was fine

S Griffin stated that in the text revert to the maximum value

J Millard stated he will put the 10,000 pCi/g value in text

S Griffin stated the statistical parameters should be in an appendix and the only number in the text is the result chosen for the risk calculations

J Millard asked if she wanted him to explain in the text why the UCL was not being used

S Griffin stated that he could layout the flowchart text

J Millard stated that he could discuss in the uncertainty section Can have a table with the UCLs or can get rid of the tables

S Griffin stated however you want to do it

J Millard stated that he wanted to stick with the 1,000 iterations

T Hammond stated that this was the minimum

J Millard stated that 1,000 for all analytes is a lot of work

S Griffin suggested running 5,000 iterations for americium

J Millard suggested running americium at 1,000 and 2,000 iterations and determining what the percent difference is He also stated that the majority of the surface soil analytes were bootstrapped

L Butler clarified try the 2,000 iterations on americium because it is a major risk player For minor risk players the minimum of 1,000 iterations will be run

J Millard stated the if the percentage of difference is greater than 1 would need to explain the effect on risk

T Hammond stated that it would be better to put this table in the uncertainty section

S Griffin suggested running the statistics if the percentage difference is less than or equal to 1

T Hammond stated if the percentage difference is 1 or less than 1 leave at 1,000 iterations, and if greater than 1, call Carl Spreng

L Butler suggested that there are minor issues that don't impact the risk and they will not be addressed in the SEP RA revision

J Millard stated that Section 2 is being rewritten and data discrepancies will be addressed

S Gunderson asked if there were any fatal flaws

T Hammond stated no

S Griffin stated concern about the soil screening and risk calculations

J Millard stated that these issues will be taken care of in the Section 2 rewrite and in resolving data discrepancies

T Hammond stated that she wanted a new version of the SEP RA

L Butler stated that an e-version would be sent for review and a hard copy when approved

C Spreng asked if new language could be sent to the agencies before the whole document

J Millard said O K